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TWENTY-FIFTH ANNUAL REPORT

OF THE

NORTH CAROLINA AGRICULTURAL EXPERIMENT STATION

OF THE

COLLEGE OF AGRICULTURE AND MECHANIC ARTS

FOR THE
YEAR ENDING JUNE 30, 1902.

INCLUDING
TECHNICAL AND SCIENTIFIC PAPERS AND
BULLETIN No. 181.

RALEIGH, N. C.

RALEIGH:
Edwards & Broughton, State Printers.
1903.

N. C. COLLEGE OF AGRICULTURE AND MECHANIC ARTS.

THE NORTH CAROLINA

AGRICULTURAL EXPERIMENT STATION

UNDER THE CONTROL OF THE

TRUSTEES OF THE A. AND M. COLLEGE.

S. L. PATTERSON, *ex officio* Chairman, Raleigh.

J. B. COFFIELD	Everetts.
E. L. DAUGHTRIDGE	Rocky Mount.
WM. DUNN	New Bern.
C. N. ALLEN	Auburn.
J. S. CUNINGHAM	Cunningham.
A. T. MCCALLUM	Red Springs.
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P. B. KENNEDY	Daltonia.
W. A. GRAHAM	Machpelah.
A. CANNON	Horse Shoe.
HOWARD BROWNING	Littleton.
J. R. JOYCE	Reidsville.
G. E. FLOW	Monroe.
J. C. RAY	Boone.

GEO. T. WINSTON, LL. D., President of the College.

STATION STAFF.

B. W. KILGORE	Director.
W. A. WITHERS	Chemist.
W. F. MASSEY	Horticulturist.
C. W. BURKETT	Agriculturist.
TAIT BUTLER	Veterinarian.
G. S. FRAPS	Assistant Chemist.
H. P. RICHARDSON	Poultryman.
B. F. WALTON	Assistant in Field Experiments.
B. S. SKINNER	Farm Superintendent.
A. F. BOWEN	Bursar.

The Director's office is in the Agricultural Building, Raleigh; the experiment grounds and laboratories being at the Agricultural College just west of town and on the street car line.

Visitors will be welcome at all times, and will be given every opportunity to inspect the work of the Station. Bulletins and reports are mailed free to all residents of the State upon application.

Address all communications to

THE AGRICULTURAL EXPERIMENT STATION,
RALEIGH, N. C.

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LETTER OF TRANSMITTAL.

RALEIGH, N. C., June 30, 1902.

To His Excellency, CHARLES B. AYCOCK,
Governor of North Carolina.

SIR:—I have the honor to transmit herewith the report of the operations of the Agricultural Experiment Station of the North Carolina College of Agriculture and Mechanic Arts, for the year beginning July 1, 1901, and ending June 30, 1902.

Very respectfully, S. L. PATTERSON,
Chairman Board of Trustees.

LETTER OF SUBMITTAL.

THE NORTH CAROLINA AGRICUTURAL EXPERIMENT STATION,
OFFICE OF THE DIRECTOR,

RALEIGH, N. C., June 30, 1902.

HON. S. L. PATTERSON, *Chairman Board of Trustees.*

SIR:—I have the honor to submit herewith the report of the operations of the North Carolina Agricultural Experiment Station of the North Carolina College of Agriculture and Mechanic Arts, for the year ending June 30, 1902.

This report is made in accordance with that portion of Section 3 of the Hatch Act of the Congress of the United States, relating to the agricultural experiment stations and their maintenance in the several States and Territories, and which requires said stations "annually, on or before the 1st day of February, to make to the Governor of the State or Territory in which it is located, a full and detailed report of its operations, including a statement of receipts and expenditures."

Trusting that this report will prove satisfactory, I am,

Very respectfully,
B. W. KILGORE,
Director.

TWENTY-FIFTH ANNUAL REPORT

OF THE DIRECTOR OF THE

N. C. AGRICULTURAL EXPERIMENT STATION

For the Year Ending June 30th, 1902.

By the Director.

CHANGES IN THE STATION STAFF.

The present Director assumed charge of the work of the Station at the beginning of this fiscal year, July 1, 1901, in accordance with the action of the Board of Agriculture, in charge of the Experiment Station, as recorded in the report of the Director of the Station for the previous year.

Shortly afterwards Prof. C. W. Burkett, of the New Hampshire Agricultural College and Experiment Station, was made Professor of Agriculture in the college, and Agriculturist to the Station; Dr. Tait Butler, of the Kansas Agricultural College and Experiment Station, was elected Veterinarian to the Station; Mr. H. P. Richardson, of the New Hampshire College, was put in charge of the poultry work, and Mr. B. F. Walton, a former graduate of the North Carolina Agricultural College, was made Assistant in Field Experiments, to perform, in part, the work done by Mr. A. Rhodes, who resigned to accept the position of Horticulturist to the Georgia Normal and Industrial School.

WORK IN THE AGRICULTURAL DIVISION.

Practically no experimental work was found in operation in the Agricultural Division of the Station on July 1, 1901. It was, therefore, necessary not only to plan and put in operation an entirely new set of experiments to deal with our important agricultural problems, but new land had to be prepared on which to conduct the experiments. This necessarily delayed operations, and will still longer delay the obtaining of results of field experiments for publication in bulletin form, as this class of work, to be of the greatest value, must not only be carefully planned and carried out, but must be continued for a number of years, so as to make reasonably sure of the accuracy of the conclusions. A start was made at once, and a field of about sixty-five (65) acres has been cleared in part and laid out in twentieth and tenth acre and larger plats for our permanent work in agricultural lines.

The Type of Soil.—The field experiments are on the ridge to the

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southwest of the college buildings, the soil being a fairly good type of what is generally known as gray land. It is a sandy loam, six to ten inches deep, underlaid by stiff red clay. In the soil survey work of the Bureau of Soils of the United States Department of Agriculture this soil is designated "Cecil Sandy Loam."

Experiments with Cotton.—Forty-seven one-twentieth-acre plats of this land are devoted to experiments with cotton, in testing flat as compared with ridge culture, and frequent in comparison with infrequent cultivation; in comparing a number of the varieties of cotton as to productiveness, time of maturity, and length and strength of fiber; in growing cotton in a number of rotations with corn, grains and leguminous crops, including peas, vetch and Burr clover; in determining the yield of cotton with similar total amounts of fertilizer, but with widely varying proportions of nitrogen, phosphoric acid and potash, and with varying applications, to see what is the most profitable quantity of fertilizer to use to the acre. Tests are also included with cotton in different width rows and different distances in the rows.

These experiments were planned by the Director and Agriculturist and are practically a duplication of tests in progress for the past three years on two types of sandy soils in the eastern part of the State. A similar set will be started next spring on the red clay lands in the Piedmont section of the State in Iredell County, the idea being to obtain and bring together the results of these tests relating to cotton culture on the several type soils and sections of the State, with the view of being then better able to suggest and help introduce varieties, culture methods, fertilization, and rotations that are best suited to our different soils and sections. The experiments away from the main Station at Raleigh are being conducted by the State Department of Agriculture, and are so arranged as to fit into and supplement the Station work. In this way the two institutions, working according to one general experimental plan, hope to eventually cover reasonably well the broad field of agriculture in the State. It is certainly in need of every possible assistance and deserving of the most powerful efforts.

Experiments with Corn.—Similar tests to those referred to above are being conducted with corn, and in addition, experiments as to time and methods of planting have been added by the Agriculturist. This work with corn is also being repeated away from the main Station and along with the tests of cotton.

Grasses and Legumes for Pasture and for Hay.—Ninety to one hundred different grasses and legumes and combinations of these for pasture and for hay are being tested on small plats here, and on the sandy soils of the eastern part of the State, and next spring the same series will be put out in the Piedmont section. After a few years' tests we hope to be able, by bringing together the results obtained on the different type soils, to recommend the grasses and legumes best suited to different localities.

Beef Production.—Past and present high prices of beef lend attractiveness to the beef industry. Last winter the Station obtained in Missouri, through the assistance and courtesy of the Director of the Missouri Experiment Station, thirty-nine head of thoroughbred and high-grade beef animals of the Aberdeen-Angus breed, for the use of the Station, Department of Agriculture, and for a number of farmers in the State. Sixteen head of these were kept by the Station as a nucleus of a beef herd. It is the purpose of the Station to make beef production and dairying and grass and forage plant production leading lines of its work. To this end and to develop as fully and rapidly as possible all phases of the strictly agricultural lines of the State, the Agriculturist has been given every assistance the Station could afford and as fast as it could be used to advantage toward bringing this about.

Poultry Work.—The poultry interests of the State are more important than ever before, and the inquiries which come to the Station on this subject are frequent, intelligent and deserving of the best attention. Considerable additions have been made to the equipment of the poultry plant in the way of incubators, brooders, and stock of good breeds and breeding. To deal with the questions relating to the breeding, care and handling of poultry requires skill and experience. It is our purpose to put this phase of Station work on the highest plane it can afford.

WORK IN THE HORTICULTURAL DIVISION.

The report of the Horticulturist gives in considerable detail the work which has been carried on during the past year. The main questions under investigation have related to the growing of peaches, plums, pears and apples, the Station having a considerable number of trees of the different varieties of these several fruits. It also has a large number of varieties of grapes and strawberries under test, and has conducted experiments during the year with tomatoes out of doors and under glass, with potatoes, sweet corn, etc. An effort is being made to introduce the culture of the newer and higher priced kinds of bulbs in the eastern part of the State.

The Horticulturist's time is perhaps taken up more largely than any other Station worker, outside of the Director, with correspondence with the farmers of the State.

WORK IN THE CHEMICAL DIVISION.

The investigations in the Chemical Division of the Station are generally more technical than those conducted by the other workers. The work the past year has been principally in continuation of experiments already begun, and relate mainly to the study of the rate at which nitrogenous fertilizer materials nitrify and become available for plant food in different soils. Quite a difference has been found in the action of different soils, which is attributed to the presence or absence of bacteria in some and not in others. This work will be continued with a view to determining definitely the cause, and should it be found that bacteria are responsible for the difference, it will be interesting to follow the matter further and see if it will be possible or profitable to handle different soils so as to get into them bacteria of the most beneficial kinds. This would be a similar experience to that with which we are all now so familiar as regards the necessity of special bacteria in connection with the growth of leguminous crops. The chemical work has also shown that sulphur is present in plants in much larger proportion that has been heretofore supposed, and that it, in fact, is as abundant in many cases as phosphoric acid, which makes it desirable to make a closer study than ever has been done in regard to the effect of sulphur as a fertilizer for different crops and soils. Other work in the Chemical Department has been in the study of methods for the analysis of various materials.

Papers of a more or less technical nature, giving the results of chemical work, are included in this report, as follows:

I. Nitrification in Different Soils.
II. The Determination of Sulphur in Plants.
III. The Determination of Sulphur and Chlorine in Plants.
IV. The Solubility of Barium Sulphate in Ferric Chloride, Aluminium Chloride, and Magnesium Chloride.
V. The Sulphur Content of Some Vegetable Materials.
VI. The Determination of Pentason-free Crude Fiber.

WORK IN THE VETERINARY DIVISION.

By far the greater portion of the time of the Veterinarian has been occupied in work relating to the extermination of the cattle tick, or the inoculation of cattle, to render them immune against tick or Texas fever when put on tick-infested pastures. Twenty-two head of the Northern cattle purchased last winter were thus inoculated. One animal died from the fever produced by this treatment, the rest having lived and done well, though they are carrying large numbers of ticks. The data obtained in this work will be used when further added to for a bulletin on the subject.

The beef cattle brought from the North have attracted so much attention that a large number of requests have come to the Station for similar ones, and we are now arranging to purchase a further lot for farmers in different parts of the State, who have already placed their orders for animals. It would be unsafe to put cattle obtained north of the tick line on tick-infested pastures, on account of the heavy loss from death, which would certainly follow. To aid farmers in this matter the Station is offering to inoculate free cattle obtained beyond the tick line, and which are subject to the fever.

FARMERS' INSTITUTES.

The Station has aided the Commissioner of Agriculture in conducting Farmers' Institutes by sending members of the staff whenever called on by him for this duty. We consider this a most valuable phase of agricultural work—one which should be encouraged and extended in every way possible.

PUBLICATIONS.

On account of there being no completed work at the beginning of the fiscal year and very little in progress at that time, no results have been available for publication during the year, except from the Chemical Division, which has furnished a number of papers, already referred to in this report, and occurring elsewhere in it. These might have been issued as one or more technical bulletins, but it has been decided to make the annual report the medium for distributing and preserving this class of investigations, reserving their publication in bulletin form until the work has progressed and been tested sufficiently to warrant deductions that are susceptible of application by the farmer.

Only one *Bulletin* has been issued—

No. 181—Silk Culture, by Gerald McCarthy.

And three press *Bulletins*—

No. 1—Silk Worm Feeding Chart.
No. 2—So-called "Cabbage Snakes."
No. 3—Anthracnose or "Black Rust" of Cotton.

Press *Bulletins* on timely subjects and containing matter of immediate interest and usefulness to the farmers are being issued frequently now, and it is proposed to make them a feature of the Station publications. They do and will contain concise information most frequently asked for by farmers in their correspondence with the Station.

CORRESPONDENCE AND CONCLUSION.

The large number of letters of inquiry which come to the Station covering the various phases of farm operations show that our farmers are interested in the Station and its work, and are looking to it for assistance in their farming matters.

It is our hope and purpose to make the Station more and more indispensable to the farmers of the State as the years go by. They are invited to treat it as their own and to come to it for help on all matters relating to their work. We shall be glad to advise with them regarding their operations, and shall in like manner be glad to have them suggest and advise with us in the conduct of our and their experimental work.

REPORTS OF HEADS OF DIVISIONS AND FINANCIAL STATEMENT.

The reports of the heads of the several divisions of the Station's work and the financial statement follow:

REPORT OF THE AGRICULTURAL DIVISION.

PROF. B. W. KILGORE, *Director.*

SIR:—The work of the past year in the Division of Agriculture has been primarily along preparatory lines for investigations. The first thing done in the division, after assuming the duties of Agriculturist, was the selection of suitable grounds for experimentation and the separation of twentieth and tenth-acre areas for plot experiments. A site was selected early in the season for permanent work and now about 400 plots are available and being used the present year.

AGRONOMY AND PLANT PRODUCTION.

The four hundred plots used for investigation in agronomy and plant production are employed in the following lines of work:

1. Soil improvement by means of leguminous crops and fertilizers.
2. Method of culture, varieties and fertilization for cotton.
3. Method of culture, varieties and fertilization for corn.
4. Testing of varieties, methods of culture and fertilization for cow peas.
5. Wheat culture in relation to cow peas.
6. Forage crops and grasses.

The work in these several lines is of a permanent nature and outlined to cover a series of years. The work will be enlarged so as to cover all new questions arising from the investigations now begun.

WORK WITH POULTRY.

The poultry plant is a permanent feature of the Station, and in the change of location and enlarged conditions of the work, the division will be enabled to carry on work of considerable importance in egg production, the raising of fowls in practical and economical ways, feeding rations for poultry, comparing incubators, fertility of eggs, etc.

For successful work in poultry raising, range must be provided. The fact is clearly proved that close confinement makes poultry raising unprofitable.

FEEDING HORSES AND MULES.

During the past year the division has conducted feeding experiments with the college horses and mules. A great many feeding stuffs have been compared and the effect of feed and labor on weight recorded. At the end of the feeding period, which is twelve months in length, the result will be presented in bulletin form.

BEEF PRODUCTION.

The division, believing the beef industry of growing importance in this State, early in the year secured a nucleus beef herd, for investigation in breeding, raising and managing beef cattle under Southern conditions.

An Aberdeen-Angus bull and two heifers of pure breeding, and several high-grade heifers of the same breed, were purchased.

The division will make its investigation along the lines of raising beef animals, comparing some of our breeding stuff for beef production, comparing the well-bred with the native stock, and the adaptability of beef raising to the agriculture of the State.

THE DAIRY INDUSTRY.

Since a good part of the manufactured dairy products used in the State is brought from other States, it follows that the dairy industry is one of great and growing importance. This is doubly so on account of the marvelous development of manufacturing interests in the State. The division is giving careful attention to dairy education. The improvement of dairy stock and the production of milk and butter. The whole college herd, of fifty cows, are used in this investigation. The lines being considered are: The cost of producing milk and butter with Southern feeds and under Southern conditions; the milk and butter capacity of dairy cows; comparison of feeding stuffs raised in the State, etc.

A careful record of each cow is being kept. The milk of every cow at every milking is recorded and sampled for determination of butter contents. Other phases of dairying are also being studied.

Respectfully submitted, CHARLES W. BURKETT,
Agriculturist.

REPORT OF THE CHEMICAL DIVISION.

PROF. B. W. KILGORE, *Director*.

SIR:—I have the honor to submit the following report of the work of the Chemical Division for the year ending June 30, 1902:

PLANT NUTRITION.

Minimum Requirements of Plant Food for Crops.—These experiments, which were begun in 1899, and which are referred to in reports of the Station previous to this, have been continued during the year.

Studies in Nitrification.—The work of this division during the year previous* led to the belief that in different soils may be found different nitrifying organisms. To test this theory ammonium sulphate and cotton-seed meal were submitted to nitrification in eleven soils of various sources, both with and without the additon of calcium carbonate. The soils came from North Carolina, Florida, Massachusetts and Rhode Island. The results of the work show that in some soils nitrification of ammonium sulphate took place more rapidly and in others less rapidly than cotton-seed meal, thereby serving to confirm the theories advanced to explain the results of our previous work.

An article containing the result of this work is submitted herewith. A report of the work was read before the Association of Official Agricultural Chemists at its meeting in 1901, and appears in the printed report of the proceedings of that meeting. It also appears in the Journal of the American Chemical Society for 1902, pages 528 to 534.

Since the completion of the work referred to we have treated chabazite with an ammonium salt and subjected the product after washing to nitrification by various soils in comparison with ammonium sulphate and cotton-seed meal. The soils used by us nitrified ammonium sulphate less rapidly than cotton-seed meal, but in every case the ammonia fixed by the chabazite was nitrified more rapidly than either of the other nitrogenous materials. Some further experiments along this line are in progress.

COMPOSITION OF PLANTS.

Sulphur in Plants.—It has been customary heretofore to estimate the amount of sulphur in plants from the analysis of the ash. In making an investigation of the method for determining sulphur, it was ascertained by this division that a large part of the sulphur in plants was driven off by burning and did not appear in the ash. In consequence of this the sulphur content of various plants has been estimated too low and the importance of that element, so far as quantity is concerned, at least, has been under-rated.

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*24th Annual Report, pp. 8, 9, and 13–24.

The number of samples analyzed was as follows:

Cotton-seed meal	10
Cotton-seed hulls	6
Cotton-seed kernels	2
Lint cotton	3
Tobacco	4
Kernels	2
Peas	6
Corn	8
Beans	18
Peanuts	3
Onions	1

As a result of this work it has been found that instead of sulphur being present in plants in almost insignificant quantities, in some cases it is present in very much larger quantities; in many cases surpassing that of phosphoric acid, lime, magnesia, and even potash.

METHODS OF ANALYSIS.

Determination of Sulphur in Plants—As stated above, it has been found that much of the sulphur in vegetable materials is driven off by burning, and does not remain in the ash, consequently, the sulphur found in the ash does not truly represent the amount present in the entire plant. This division proposes a method which is described in an article submitted herewith, together with the experiments connected with the work. The result of this work is reported in the Journal of the American Chemical Society, pages 24, 346, and to the Association of Official Agricultural Chemists. (See Proceedings 1901.)

Determination of Chlorine in Plants.—The object of our work was to devise a satisfactory method for the determination of chlorine in plants. A report of the work is submitted herewith.

Solubility of Barium Sulphate.—In the work on the determination of sulphuric acid in soils, Mr. C. B. Williams, Assistant Chemist in the North Carolina Department of Agriculture, found that considerably more barium sulphate was obtained, when the iron and aluminium had been previously precipitated from the soil solution. As the precipitation of the barium sulphate takes place in the presence of these salts, the accuracy of the determination of sulphur depends upon the solubility of barium sulphate. A paper embodying the results of this investigation accompanies this report. The same paper has appeared in the American Chemical Journal [*27*, 288 (1902)].

Determination of Pentosan-free Crude Fiber.—When crude fiber is determined in feeding stuffs according to the methods of the Association of Official Agricultural Chemists, it contains pentosans in addition. To remedy this difficulty, a determination should be made of the pentosans in crude fiber, or there should be a method for obtaining a crude fiber which should be free from pentosans. Attention has been called by this Division to a method devised by J. Konig for obtaining pentosan-free crude fiber. Tests of the method were made with satisfactory results. A paper containing the results of this investigation accompanies this report. The same was read before the Association of Official Agricultural Chemists at its meeting in 1901, and is to be found in the printed report of the proceedings of that meeting.

CONCLUSION.

I desire to express my high appreciation of the work of Dr. G. S. Fraps, Assistant Chemist.

Very respectfully,
W. A. WITHERS,
Chemist.

REPORT OF THE HORTICULTURAL DIVISION.

PROF. B. W. KILGORE, *Director*.

DEAR SIR:

I have pleasure in reporting that the plantation of fruit trees is in a very thrifty condition, and so far has not been troubled by attacks of insects, except the ever present Curculio. The peaches and plums, most of them, bore their first fruit this season. This is true of the Japanese and American plum varieties. The domestic sorts of European origin have not yet fruited. Plums of the varieties fruited seem to come to normal size and perfection where they did not rot. The rot was quite bad with some sorts. The Burbank plum rotted bodily, though the crop set was a full one. It is evident that spraying with fungicides must begin with the plums at an early stage in the season and before any swelling of the buds, as the fungi seem to gain entrance by the blossoms. I hope to have better success in checking the rot another season. The plums and peaches were sprayed with arsenite of lead as a check to the Curculio. If the spraying had been repeated more frequently there would doubtless have been better results. Another season I shall use the jarring method, and the gathering of bitten fruit and insects, as well as the arsenite. The arsenite of lead has the advantage that it does not injure the foliage of peaches as Bordeaux mixture and Paris green are certain to do. One row of peaches most exposed to the sun was sprayed all over with whitewash for the purpose of retarding the bloom by whitening the shoots, thus reflecting the heat. Though rain came directly after washing, the whitewash on many of the trees remained sufficiently to show that it did have some effect in retarding the bloom, as the trees were somewhat later than others down the slope north of them. In a general way I have to report that the peaches in our red clay soil here do not seem to attain the size or have the color that they do on lighter soil elsewhere in the State. From the lack of characteristic color it is hard to recognize varieties with which I am perfectly familiar. I have noticed this fact elsewhere in the neighborhood of Raleigh, and it leads to a serious doubt as to whether the growing of peaches can ever be made a commercial success here. A few rows of the peach trees have been left uncultivated, but the ground liberally manured. This, too, is for the purpose of testing the effect on the retarding of the bloom in spring, since it has seemed that trees well cultivated in the early season start into bloom sooner than those in uncultivated land.

By manuring these trees have made fully as good a growth as those in cultivated ground. In fact, the growth of all the trees is as strong as there can be any wish for. The pear and apple orchard is doing well. These were cultivated all through the early part of the season, and then peas were planted in rows between the trees, and these were cultivated till July, when cultivation stopped, in order that the trees may fully mature their growth.

GRAPES.

Two years ago, by the courtesy of the Georgia Station, I received cuttings of 300 varieties of grapes. These were rooted, and last year were planted in a small vineyard for trial. Last year the season was against them and the land very poor and unmanured. Hence, the growth was small. This season they have been well manured and have had a top dressing of nitrate of soda, and have been kept to a single cane. The growth has been fine and they will be ready for the trellis the coming spring. I propose to use the same shelter trellis that I found so successful at Southern Pines. This is a modification of what is called the Munson trellis, and it is found that there is far less tendency to rot on such a trellis. The trellis is made by setting stout posts along the rows ten feet apart and nailing strong cross pieces to the tops four feet from the ground. Three wires are stretched, one along the tops of the posts and the others at each end ot the three-foot cross pieces. The arms are then taken along the central wire and the fruiting shoots hang over the outer ones and form a complete shelter to the fruit beneath. My experiments years ago showed that a board coping over a trellis was just as effective in preventing rot as the most careful spraying, and this method of training has some of the effect of the board coping. Two rows of peas have been planted between the rows of grape vines for the purpose of furnishing organic matter to the soil.

TOMATOES.

The experiments in growing tomatoes under glass were continued the past winter. Heretofore I have been forcing the tomatoes in large pots. The past season I planted them in a solid bed in the centre of the greenhouse. This bed was made of a well-prepared compost of rotted sods and manure, and had a top dressing of stable manure after the plants were set. But two varieties were planted—Maule's Earliest and the Dwarf Champion. Twenty-six plants of each were set. The growth was all that could be desired, and the crop was a good one. A heavier crop would have been had, had the blossoms been more regularly fertilized with pollen. As there are at that time no insects to help in this, the setting of the blooms must be done by hand. I had to depend for this largely on the help of inexperienced students.

and after the plants got very tall it was not done as fully as it should have been, and many very small tomatoes resulted. The plants were trained to single stems, and grew nearly ten feet high during the season. From the 26 plants of Maule's Earliest we gathered 268 pounds of tomatoes, and from the 26 plants of Dwarf Champion 142 pounds of fruit. The Dwarf Champions were largely overshadowed by the more rapid growing plants of Maule's Earliest, and if the whole bed had been set with them the result would have perhaps been better. The fruit of Maule's Earliest is inclined to be rough and wrinkled, while that of Dwarf Champion is uniformly smooth. The Earliest would be a first-class forcing tomato if it could be bred into a smooth shape. The result showed that if we had a house properly suited to the tomato, which the college houses are not, the winter forcing of tomatoes can be made a profitable business, and when our market growers fully realize and learn what can be done in our sunny climate under glass, the business will develop greatly. In the open ground I have grown this season 26 varieties of tomatoes. This fruit has now been brought to such a degree of perfection that there is little to choose between the leading varieties. My plantation was more for the purpose of observing the degree of resistance of the varieties to the Southern Blight, and to select seed from resistant sorts. The results this season have been rather of a negative character, since the land in which the plants were set has probably never before been planted in tomatoes, and is not as yet infected with the Blight bacteria, so that no disease has appeared. This very fact, however, shows the importance of avoiding land where tomatoes or potatoes have recently been grown. It has long been noticed that the small plum-shaped tomatoes are uniformly resistant to the Blight. In hope of getting some of this resistant quality in tomatoes, I have saved seed from some of the finest of the larger tomatoes crossed with these small and resistant ones, and will use these in our work another season.

LETTUCE.

The growing of frame lettuce during the winter under cloth and glass has developed to such an extent in the eastern part of this State that it was thought that some experiments with fertilizers for this crop would be valuable. It was planned to make this experiment in frames covered with glass. There were two lines of frames with 24 and 18 sashes, respectively. The sashes are the ordinary hot-bed sashes, 3 by 6 feet each, and the plots were arranged to take two sashes each. For the purpose of getting an unaltered soil the frames were excavated and a soil collected from a thin, poor piece of woodland mixed with washed sand was filled in the place of the soil removed. This soil was found to be exceedingly deficient in all the elements of fertility. The following plan of fertilization was adopted, placing the normal application of nitrogen, phosphoric acid and potash at 100 pounds per acre, N in the table standing for 100 pounds per acre of nitrogen, P for phosphoric acid, and K for potash, in same amount:

	FIRST FRAME.		SECOND FRAME.
Plot 1.	K P.	Plot 1.	N. P.K. and stable manure.
2.	K. N.	2.	N. P K.
3.	N. P.	3, 4, 6, 7, 8, 9	N. P. K.
4	N P. K.	5.	O.
5.	N_2 P. K.		
6.	O.		
7.	N. P_2. K.		
8.	N. P. K_2.		
9.	2 (N. P. K.)		
10.	½ (N P. K.)		
11.	N P. K. L		
12.	N. P. K. L. S.		

The plots 3, 4, 6, 7, 8, 9 were intended for a variety test, but the plants failed, and only one variety, the Big Boston, was used. This is the variety most commonly grown by the market growers. The result of this experiment seems to show that in our clay soil commercial fertilizers alone will fail to make good lettuce. The crop in these frames was very slow in growth, and the product of all the plots was inferior, and sold for less than half the price obtained for first-class lettuce. The average weights of all the heads was four ounces, while plants raised from the same seed, sown at the same time, but treated in a commercial way, made heads weighing . . . . pounds and over, and were sold and the frames replanted before any of this lettuce was headed. The frames in my home garden were filled with a well rotted compost of sods and stable manure, and a complete fertilizer applied in addition at rate of one ton per acre. In our clay soil here well rotted stable manure is essential to the production of fine lettuce in winter. The plots having some stable manure made better lettuce than the others, but the manure was of too coarse and fresh a condition to give the best results. A tabulated statement of these plots will be given in bulletin on this work. It is found that with glass sashes and mats to cover them in very severe weather we can grow as good lettuce, or better, than the growers in the eastern part of the State get under their cloth covers. In the long run the glass is the cheaper of the two, and when our growers find out the value of glass fully they will abandon the use of cloth.

The variety tests planned for the lettuce were not carried out be-cause of the partial failure of the fertilizer crop, and the fact that it occupied the frames during the entire winter. I am planning for a very complete variety test of lettuces during the coming winter, as it is of the greatest importance to our market growers to find the variety best suited to their work. From results gotten in my home garden I am of the opinion that no one variety will be found suited for the entire season from December till May. A rather smaller and earlier variety, like Rawson's Hothouse lettuce, will be best for the December and Christmas market, a plentiful supply of plants of the Big Boston being in the meantime provided for the immediate replanting of the frames. This crop will come off in March, and after this there is a strong demand for Southern lettuce that should be met during April, when the price is apt to be higher than at any other time. For this crop we have found a large wrinkled leaf variety, similar to the Hanson, and called the Wonderful, which is admirably suited. If frames are set with this, and only protected by cloth or glass in the most severe weather, simply enough to prevent their being killed, they will come on at the right time and will make immense heads of great solidity, weighing from two to four pounds. I am inclined to think that our market growers will find this about the most profitable crop. The Wonderful lettuce is not suited to the winter heading crop, as it will not head well till spring. But for the spring crop during April it promises to be the best, so far as our experiments have gone. With a specially prepared compost and heavy additional fertilization it is hoped to demonstrate the value of the three-crop system of growing frame lettuce in the South. The first sowing of seed will be made as usual the third week in August, and other sowings of Big Boston and Wonderful from first to middle of September. By the use of glass sashes and mats the crop of winter frame lettuce can be grown successfully in any part of the State east of the Blue Ridge as successfully as in the market garden region of the Eastern section. I estimate that it will require an expenditure of $4,000.00 to cover an acre with frames and glass sashes, and that the first winter and spring crop will pay for the sashes and frames, while the cost of cloth covered frames is fully $500 per acre, and the cloth has to be renewed every two years, and sometimes in one season, while the sashes are good for twenty years, at least, if taken care of. I have now sashes that have been in use for thirteen years and are still in good shape. Hence, in the long run I think the market growers will find the glass not only better than cloth, in giving a better product, but cheaper.

For covering the sashes in very cold nights I am using at the Station mats made of broomsedge, woven on strands of tarred twine. These were made by the students and farm hands, and have been in use two winters, and are still good. I have also in my private garden mats bought in New York. These are six feet square and are made of two thicknesses of burlaps with waste wool quilted between. These I find to keep out frost completely, and with their protection I had hyacinths, tulips, narcissus, violets and freesias in bloom during the winter in my frames.

This fact opens up another prospective industry for Eastern North Carolina. Roman hyacinths, violets and narcissus are forced in the North extensively in steam and hot-water heated greenhouses. Here we can produce just as good flowers in a simple frame covered with glass, and as our florists get many cut flowers from the North all winter in good shape after having been cut and sent to the commission merchants in New York, it would be perfectly easy, with the present means for transportation, to pack and ship the cut flowers to New York and other Northern cities during the winter, where our growers could afford to sell at far lower prices than the Northern growers can. The forced bulbs used in the heated houses North are worthless after the forcing, while those grown more naturally in the frames really increase in value, as they can be left to fully mature while the sashes are removed to extra frames for later use. The uses that can be profitably made in our climate of a simple frame and sash are innumerable, and the use of glass opens up a business, the profit of which our growers can as yet have no conception.

ROSES.

During the season of 1901 I planted and grew some thousands of roses of various kinds in the open ground for one of the Northern dealers. The plants were sent here already rooted and were set in rows for cultivation by horse power. The crop was dug and shipped in the fall of 1901. Though there was a heavy loss of plants from the first shipment, having been sent too early, and being caught by a hard freeze just after setting, the result showed that a gardener here could make a fair profit by growing these contract roses.

The business of producing field-grown roses is gradually coming to the South, since with our longer season we can produce a better plant than the Northern growers, and there is a tendency among the larger dealers and growers there to have their roses grown in the South. But the profit in this business would be far greater if the growers here would prepare to propagate the plants at home and then go on the market at regular rates with their stock. The roses we grew during the year past were grown for $2.00 per 100, the Northern house paying the freight both ways. The regular trade prices for these roses varies from $50 to $150 per thousand, according to the value of the variety. Hence, it is easy to see that a grower with plenty of stock plants here, and facilities under glass for propagation can make a larger profit than by growing on contract. And here the simple sashes and frames come into play again. With a single house for rooting the cuttings they can be potted into small pots and wintered in the frames ready for the spring planting, or for sale during the winter as young pot plants. This opens up a business in which large capital can be safely and profitably invested, and at least one Northern firm has bought land in the South and is erecting houses and frames for this purpose. Intensive horticulture is just in its infancy in the upper South. Our growers have learned the profit there is in the slight protection of the plant cloth, and little by little they will grasp the opportunity for enlarging their operations by the the use of glass.

IRISH POTATOES.

In the section about Raleigh there has seemed to be a particular difficulty in the way of getting profitable crops of early Irish potatoes, and the result is that nearly all the early potatoes sold in our market are brought here from the South or the eastern part of this State. I endeavored to make a small variety test, using two of the older varieties, the Early Rose and Early Ohio, for comparison with a number of newer sorts. They were planted in the best soil we have for the potato, a soil well suited to the crop. I used in the furrow under the potatoes a fertilizer composed of dried blood, sulphate of potash and acid phosphate, these being the materials at hand. The mixture was calculated to contain 4 per cent nitrogen, 8 per cent phosphoric acid and 7 per cent potash. This was used at rate of 1,000 pounds per acre. One peck of each variety was planted, and the weights of the crop are given below. The growth in the early part of the season was fine, until the hot and dry weather set in, and but for this the crop would have been a very fine one. The plants were sprayed twice with arsenite of lead, which cleaned up the beetles and their larvae. No Bordeaux was used, and little or no blight was observed. Like the tomatoes, the potatoes were on land which had probably never been used for the crop before. Hence, the freedom from blight. The earlier varieties, it will be seen, made a larger crop than the later ones, as these were more seriously damaged by the drought and heat on land of a peculiarly thirsty nature.

Variety.	Comparative Earliness.	Weight of Crop.
		Pounds.
Early Ohio	1	148
Early Red Bose	2	130
Early Rose	2	160
Thoroughbred	3	200
Commercial	5	110
Freeman	4	98
Bovee	5	285
Sir Walter Raleigh	5	186
Junior Pride	4	150
Early State of Maine	4	160
Total		1,627

The yield of the entire plot was at the rate of 108 bushels per acre, not a large crop, but showing that in suitable soil here we can grow a profitable crop of early potatoes and can sell them readily in the local market, in a season of normal moisture and temperature.

SWEET CORN.

There has always been a serious difficulty in getting an early sweet corn with stamina sufficient to succeed in this climate. The later varieties of Sugar Corn give fair crops, but it is very hard to get an early one that is of any value here. The trouble arises largely from the fact that our people regularly get seed of the sweet corn from the seedsmen, and this seed is produced in the North and is not acclimated here. We planted this spring the following varieties in order to get completely cross fertilized seed, from which we may develop by selection a variety that will be early enough and which will grow well here. Some years ago I undertook this by crossing the Leaming and the Mammoth sugar corn. This was selected for seven years, till I finally had a well fixed variety of fairly good and early corn, which made a sufficient growth of stalk and had good-sized ears. The fault of this variety was a shallow grain and large cob. Still, it was well suited to our conditions. After leaving Southern Pines I had no place for the corn, and so the crop was distributed all over the State, with the notice that no more would be grown here and that the recipients would have to take care of it. I believe that this corn is no longer in existence, and I now propose to select and grow a pure, sweet corn without any cross of field corn, and hope that in a few years I may be able to select and fix such a variety as will have sufficient growth and produce a fairly early crop for table use. Such a corn is badly needed by our market growers, who now depend mainly on such varieties as Adams' Early for the early market, though this is not a sugar corn, but a small early Dent variety. The varieties planted this season for crossing were: First of All, Cory, Early Sheffield, Early Champion, Stabler's Early, Mammoth Cory, Maule's XX, Nonesuch, Black Mexican, Kendall's Early Giant, Perry's Hybrid, Improved Giant, Metropolitan, Maule's Mammoth, Zigzag Evergreen, Stowell's Evergreen and Everbearing Egyptian.

The varieties most promising for this climate, and the ones that should be used here in breeding by selection for a variety for our use are the following: Country Gentleman, Zigzag Evergreen, Mammoth, Maule's Mammoth and Stowell's Evergreen. These will all do fairly well in favorable soil, when grown from Northern seed, and when carefully selected here will doubtless improve in adaptation to the climate. I should have included in the above list the Egyptian, a large corn of sturdy habit, that has been developed in Maryland, and is perhaps at present better adapted to our climate than any other.

THE PRODUCTION OF FLOWERING BULBS FOR FLORISTS.

For many years the growers in Eastern North Carolina have been supplying the markets of New York and London with nearly all the tuberose bulbs used by the florists of America and Europe. Owing to the fact that there is a smaller demand for these than formerly, the price has fallen so that the business is not as profitable as it once was. Hoping to introduce the culture of other bulbs, which are now imported in immense quantities from Europe and Bermuda, I began several years ago to experiment in the culture of these bulbs here, and especially with the Bermuda Easter Lily, which is now imported to the extent of about a million dollars worth annually. I was enabled to do this through the liberality of the Northern dealers, who are interested in the development of the culture here, and sent me quantitis of bulbs for trial. Last year, finding the soil at the Station farm unsuited to this work, I determined to continue the experiments at my own expense on better soil in my home garden. With some bulbs I have had fairly good success, but with the most important one, the Easter Lily, I have not as yet produced as fine bulbs as I could wish, and I have found that the local conditions in this part of the State will render the culture uncertain. Our soil dries out too rapidly and the bulbs are stunted by drought. On the level black soils in the eastern part of the State, such as are used so successfully for the growing of strawberries, I feel sure that the lilies will be a success. A paper which I presented at the meeting of the Society of American Florists at Asheville this summer, attracted attention, and it is hoped that further experiments will be made in the eastern part of the State, for which I can furnish a large amount of sets for planting this fall.

In Southeast Virginia a company with abundant capital has started in the business of growing bulbs, and is being successful with the same kinds that I have succeeded with here, but I am not informed whether they have grown the Bermuda Lily with success. All that is needed in Eastern North Carolina is the investment of capital in the work and the employment of skilled men to attend to it.

CANTALOUPES.

Some years ago the town of Rocky Ford, Colorado, came into note by reason of the excellence of the cantaloupes grown there. The business has increased there to a large extent and hundreds of car loads of Rocky Ford melons are sent East and sold at paying prices. The seedsmen put the Rocky Ford melon in their catalogues as a new variety. It was soon found, however, that it is simply the old Netted Gem melon, varied by soil and climate, and it became a matter of interest to study the variations produced by climate on this melon. The Department of Agriculture at Washington asked me to undertake the culture of this melon and send them samples for chemical analysis, as they proposed to have them grown in a variety of climates for this purpose. The unfavorable season last year was against the success of any melon, owing to the continual wet weather. Hence, the Department has asked that the experiment be continued, and I have again planted this melon from seeds sent by the Department, but after repeated plantings have a poor stand of plants, and I am inclined to believe that the Rocky Ford growers have palmed off some poor seed on the Department. Enough will be produced for the purpose desired, I suppose, and I shall look for the result of the analysis with interest.

FOOD CROPS.

Having to support a team of horses, it became necessary to add some forage to our regular work. A portion of land was sown last fall to winter oats and hairy vetch, which has made a fairly good crop, notwithstanding the fact that there was some winter killing of the oats. I have planted also cow peas, some of which were planted as early as the first of May and some later, and the sowing will be continued after the oats grown for hay have been cut. The early ones have been planted in rows and are to be cultivated, and it may possibly be found that this is the best way to grow them, as less seed is needed. The results will be given hereafter, as the late ones will be broadcasted.

BOTANICAL.

In the line of botanical work my efforts have been confined to the identification of plants sent in by correspondents. These have been mainly grasses, and the number of specimens sent shows that our people are taking more interest every year in the native grasses. I have in every case written carefully and fully in regard to the specimens sent, and have endeavored to advise in regard to culture, etc.

ENTOMOLOGICAL.

A great many correspondents send me specimens of insects for identification and advice. In most cases I have been able to make an intelligent reply, but am glad to know that the Station now has the services of an expert Entomologist.

Respectfully submitted,
W. F. Massey,
Horticulturist.

REPORT OF THE VETERINARY DIVISION.

PROF. B. W. KILGORE, *Director.*

DEAR SIR:—I beg to submit the following report of the work done by the Veterinarian of the Experiment Station during the past year.

The work has been confined to a study of the problems involved in the extermination of the cattle tick (Boophilus Annulatus) and inoculation, for the prevention of Texas or tick fever. Twenty-two head of Northern cattle have been inoculated and placed upon tick-infested pastures. They are all living and doing well. The temperatures of these animals were taken once and twice daily for two months, and the effect of the disease upon the number of red corpuscles in the blood observed.

It is proposed to continue this work and extend the observations upon the blood of cattle the first summer after inoculation, as compared with that of cattle immunized in the natural way. When the work has been completed and sufficient data obtained the results will be offered for publication.

Yours respectfully,
TAIT BUTLER,
Veterinarian.

North Carolina Agricultural Experiment Station in account with The United States Appropriation, 1901-1902.

DR.

To Receipts from the Treasurer of the United States as per appropriation for fiscal year ended June 30, 1902, as per act of Congress approved March 2, 1887	$15,000.00

CR.

By Salaries	$8,203.77
Labor	1,585.45
Publications	80.82
Postage and stationery	117 60
Freight and express	250.30
Heat, light, water and power	9.03
Chemical supplies	62 16
Seeds, plants and sundry supplies	190.42
Fertilizers	90.42
Feeding stuffs	568 27
Library	12.97
Tools, implements and machinery	270.08
Furniture and fixtures	20.50
Scientific apparatus	49.00
Live stock	2.890.87
Traveling expenses	58 55
Contingent expenses	210.00
Building and repairs	329.79
Total	$15,000.00

We, the undersigned duly appointed auditors of the Corporation, do hereby certify that we have examined the books and accounts of the North Carolina Experiment Station for the fiscal year ending June 30, 1902; that we have found the same well kept and classified as above, and that the receipts for the year from the Treasurer of the United States are shown to have been $15,000.00 and the corresponding disbursements $15,000.00, for all of which proper vouchers are on file, and have been by us examined and found correct, thus leaving nothing.

And we further certify that the expenditures have been solely for the purposes set forth in the Act of Congress approved March 2, 1887.

(Signed) S. L. Patterson,
B. W. Kilgore,
Auditors.

(Seal.)
Attest: A. F. Bowen,
Custodian.

Nitrification in Different Soils.

By W. A. WITHERS, A.M., CHEMIST, AND G. S. FRAPS, PH.D , ASSISTANT CHEMIST.

In a previous bulletin of this Station (No. 176, November, 1900) were published the results of the nitrification of different fertilizer materials in a pasture soil. The order of nitrification in the soil used was dried blood (most nitrified), cotton-seed meal, dried fish, tankage, bat guano, bone and ammonium sulphate. Excluding the ammonium sulphate, this is the order of availability of the nitrogen in these fertilizers, as measured by vegetation tests, and solubility in permanganate of potash. When calcium carbonate was added to the soil the nitrification was greatly accelerated, and the order became dried blood, cotton-seed meal, dried fish, bat guano, tankage, ammonium sulphate, bone.

Results of two experiments by other workers were cited, in one of which ammonium sulphate was nitrified to a greater extent than dried blood and other materials tested, and in the other the ammonium sulphate was nitrified less than oil cake, fish guano and dried blood, whether calcium carbonate was added or not.

In view of the general opinion held in regard to the value of ammonium sulphate as a fertilizer, these results may seem extraordinary. It is probable, however, that plants can assimilate ammonium salts as well as nitrates, just as they can get carbon from sugar as well as from carbon dioxide.

The following explanation was advanced for the results of the experiments just cited:

There are three possible ways to account for the slow rate of nitrification of ammonium sulphate.

1. Ammonium sulphate may hinder the action of the nitrifying organisms. This explanation will not account for the beneficial action of calcium carbonate.

The assumption that ammonium sulphate hinders the action of the nitrifying organism would explain the low rate of nitrification of ammonium sulphate that we have obtained. It would also explain the results of Boname, according to which ammonium sulphate is nitrified very slowly indeed the first and second months, and very rapidly the third. In direct contradiction to the above hypothesis, however, would stand the experiments of Muntz and Girard.

These difficulties might be explained away by supposing that the ammonium sulphate affects the nitrifying germs less in some soils than in others, either on account of the different character of the soils (power of fixing ammonia, etc.), or the presence of different kinds of nitrifying organisms

2. The second explanation for the slow rate of nitrification of ammonium sulphate, compared with the other materials, is that the nitric and sulphuric acids formed are detrimental to the nitrifying organisms, being neutralized only in part by the bases of the soil. When calcium carbonate is added, it neutralizes the acids, with consequent acceleration of the change. This explanation is probably applicable, but does not explain all the facts, for, if so, the addition o

calcium carbonate would remove the unfavorable conditions, and place ammonium sulphate at the head of the list—which it does not do.

3. The third explanation is, that different soils contain different nitrifying organisms, some of which convert organic matter directly to nitrites, while others change ammonium salts to nitrites more readily. The nitrites are then converted to nitrates. In soils containing the first kind of organisms, and few of the second, organic matter would be converted to nitrites more rapidly than ammonium salts would be, as was the case in the experiments of Boname, and those here described. In soils in which the second class of organisms predominate, ammonium salts would be nitrified more rapidly than organic compounds. This hypothesis would explain all the experiments here cited.

It appears very probable that all three of the explanations given above apply, and that all three are in operation, one exerting a greater influence in some soils than others.

It was our object to test the last hypothesis, and the results of the experiments will here be detailed.

Since the bulletin above alluded to was printed, the following additional work has come to our notice:

P. Boname (Exp. Sta. Record, 12, 836), in continuing experiments of previous years, obtained the following results:

TABLE I.

NITRIC NITROGEN (IN MGR.) IN 100 GRAMS SOIL.

	Jan. 24.	Feb. 12	March 4.
Soil Alone	6.	6.8	6.8
Ammonium Sulphate	7.	17.	27.
Dried Blood	18.	37.	50.
Fertilizer	31.	85.	94.
Ammonium Sulphate and Lime	8.	46.	66.
Dried Blood and Lime	21.	102.	131.
Fertilizer and Lime	41.	67.	73.

On May 20th the soil to which ammonium sulphate and lime had been added contained as much nitric nitrogen as that which had received blood and lime.

This is another case in which ammonium salts are nitrified less rapidly than dried blood.

PLAN OF WORK.

The object of the work was to study the nitrification of ammonium sulphate and cotton-seed meal in different soils, in order to see if the soils would behave differently toward these substances.

The sample of soil was sifted through a coarse sieve, and the quantity of cotton-seed meal or ammonium sulphate containing 0.3 gram nitrogen was intimately mixed with 500 grams of the soil. The mixture was then placed in precipitating jars and kept in a dark closet.

When calcium carbonate was added the amount was exactly enough to combine with all the nitric acid and sulphuric acid which would be formed if the ammonium sulphate were completely nitrified. The amount of water in the soils was about 15 per cent; at suitable periods one or more jars in each set was weighed, and the estimated loss of water was replaced in all the jars. The average moisture in the different sets is given in Table II.

At the end of three weeks, as a rule, the nitrates were leached out with 1000 c. c. water, and determined by the Tiemann-Schulze method in an aliquot portion of the filtrate. In each case correction was made for the nitrates in the soil to which no nitrogen had been added.

DESCRIPTION OF SOILS.

The soils used were as follows:

1667.—Pasture soil from the farm of this college; a light loam, containing humus, and not acid to litmus.

1668.—Heavy clay soil from the farm of this college, contains no humus, possesses low fertility, and is slightly acid to litmus.

1669.—Black garden soil from the Florida Experiment Station; contains much humus, and is acid to litmus.

1670.—Soil from the Massachusetts Hatch Experiment Station. This soil has been used in plot experiments for some time, being from a plot in field C, fertilized with sulphate of ammonia, muriate of potash, dissolved bone black, and stable manure, since 1891. This is the plot giving the least satisfactory growth, especially upon lettuce, beets, spinach and onions. It contained little humus, and was acid to litmus.

1674.—Soil from the Rhode Island Experiment Station. This soil has been used in plot experiments. Is slightly acid to litmus; contains humus.

1675.—Sandy soil from the test farm of the North Carolina Department of Agriculture, at Red Springs; contains little humus.

1676.—Soil from the Rhode Island Experiment Station. This soil is from a series of plots, which have been in use for some time, to test the effect of lime on an acid upland soil. Plot 23 fertilized with ammonium sulphate for some years.

1677.—Same as 1676. Plot 25 fertilized with ammonium sulphate and lime.

1678.—Same as 1676. Plot 27 fertilized with sodium nitrate.

1679.—Same as 1676. Plot 29 fertilized with sodium nitrate and lime.

1680.—Sandy soil from the test farm of the North Carolina Department of Agriculture at Tarboro.

NITRATES IN SOIL.

Table I shows the amount of nitrates found at the end of the nitrification period in the soils to which no ammonium sulphate or cottonseed meal had been added, *i. e.,* the blanks.

TABLE II.

Mgr. Nitrates per 500 Grams Soil at the End of Three Weeks

	Alone.	With $CaCO_3$.
1667	10.4	14.0
1668	2.5	8.4
1669	2.2	
1670	4.5	6.5
1674	16.3	17.7
1675	1.2	
1676	18.5	
1677	14.5	
1678	7.3	
1679	3.1	
1680	1.8	5.0

EXTENT OF NITRIFICATION.

Table III contains the percentage of nitric nitrogen from ammonium sulphate and from cotton-seed meal respectively. It also gives the temperature and water content of the soils.

It will be noted that nitrification was much more active in the first four soils, in which their temperature was 23 to 30 degrees C., with an average of 26 degrees. The nitrification is very much less active at 19-20 degrees C.

TABLE III.

Nitrification in Soils.

	Moisture	Temperature.		Per cent nitrified.	
	Average.	Extremes.	Mean.	Alone.	With $CaCO_3$.
1667 Pasture soil, (N. C.)	10.5	25-30°	27°c		
Ammonium sulphate				7.2	57.2
Cottonseed meal				32.4	43.6
½ ammonium sulphate					71.8
½ cottonseed meal					43.0
Ammonium sulphate and cottonseed meal					22.3
1668 Clay soil (N. C.)	13.0	25-30°	27°		
Ammonium sulphate				0.6	11.6
Cottonseed meal				10.1	—1.1
½ ammonium sulphate					43.2
1669 Garden soil (Fla.)	13.0	25-30°	27°		
Ammonium sulphate				0.2	15.8

TABLE III—Continued.

	Moisture	Temperature.		Per cent nitrified.	
	Average.	Extremes.	Mean.	Alone.	With $CaCO_3$.
Cottonseed meal				17.3	41.5
1670 Soil, (Mass.)	15.0	23–28°	26°		
Ammonium sulphate				2.2	45.7
Cottonseed meal				14.8	32.6
Ammonium sulphate and cottonseed meal				0.5	
1674 Soil, (R. I.)	10.7	20–26°	22°		
Ammonium sulphate				2.1	2.3
Cottonseed meal				3.4	4.9
½ ammonium sulphate					16.5
½ cottonseed meal					10.9
Ammonium sulphate and cottonseed meal				1.3	
1675 Sandy soil (Red Springs)	8.0	19–24°	20°		
Ammonium sulphate				.0	.0
Cotton seed meal				.0	.0
1676 Acid soil (R. I.)	12.2°	18–23°	19°		
Ammonium sulphate				.0	1.5
Cottonseed meal				—1.9	—1.3
½ ammonium sulphate					1.5
½ cottonseed meal					0.6
1677 Acid soil limed (R. I.)	11.7	18–23°	19°	.0	
Ammonium sulphate				1.0	5.6
Cottonseed meal				1.8	6.2
1678 Acid soil (R. I.)	12.1	18–23°	19°		
Ammonium sulphate				.0	0.6
Cottonseed meal				.0	.0
1679 Acid soil limed (R. I.)	12.5	18–23°	19°		
Ammonium sulphate				1.2	3.0
Cottonseed meal				2.9	10.6
1680 Tarboro soil (N. C.)	9.5	19°–24°	20°		
Ammonium sulphate				.0	—1.3
Cottonseed meal				1.3	—0.8
½ ammonium sulphate					0.8
½ cottonseed meal					4.5

NO REDUCTION OF SULPHATES.

When the previous work on nitrification was reported to the Association of Official Agricultural Chemists, inquiry was made whether any hydrogen sulphid was detected. In several series of the experiments here reported tests were made for sulphids in two ways. A strip of paper moistened with lead acetate was placed over each jar, and the soil extract was acidified and heated to boiling, a piece of lead acetate paper being placed in the neck of the flask. In no case was any hydrogen sulphid found by either method. Insoluble metallic sulphids would not be detected by this method.

EFFECT OF CALCIUM CARBONATE.

The addition of calcium carbonate to the soil always resulted in an increase in the percentage of nitrates formed, if nitrification took place at all. This is true of the nitrogenous compounds already in the soil, as well as of ammonium sulphate and cotton-seed meal. The increase is greater with ammonium sulphate than with cotton-seed meal. The greatest increases in the nitrification of cotton-seed meal when calcium carbonate is added, are from 100 to 366, 100 to 340, and 100 to 240. With ammonium sulphate, the increase is 100 to 800, and 100 to 2,100, and in some soils nitrification takes place when calcium carbonate is added, and does not take place without it.

Calcium carbonate accelerates nitrification, even when the soil has been limed, as may be seen by referring to the Rhode Island soils. With ammonium sulphate the increase is from 100 to 560 and 100 to 250 in the limed soils, and with cotton-seed meal 100 to 366 and 100 to 340.

EFFECT OF LIMING AN ACID SOIL.

Four soils in Table III show the effect of liming acid soils. In the two acid soils practically no nitrification takes place, while in the limed acid soils some nitrification takes place, though not a great amount. It is probable that more nitrification would have taken place had the temperature at which the experiment was conducted been above 19 degrees.

EFFECT OF THE APPLICATION OF FERTILIZERS.

Soils 1677 and 1679 show the effect of the application of different fertilizers to the same soil. In 1677, a limed acid soil, to which other fertilizing elements and ammonium sulphate had been applied for a number of years, nitrifies 5.6 per cent of ammonium sulphate, in the presence of calcium carbonate; the same soil which received its nitrogen in the form of sodium nitrate, nitrified only 3 per cent of ammonium sulphate under the same conditions.

It is probable that the continued application of ammonium sulphate to a soil, will increase its power to nitrify that salt, provided other conditions are fulfilled, especially if bases are provided.

VARIATIONS IN THE NITRIFYING POWER OF SOILS.

An important result of these experiments is to show clearly that different soils possess different powers of nitrification. In making comparisons of the soils, we must remember that some of the nitrification tests were conducted at a different temperature from the others, and the results can not all be compared one soil with another.

The first three soils were nitrified under the same conditions, and at the same time. Their power to nitrify ammonium sulphate is in the ratio 7:0.6:0, and cotton-seed meal, 32:0:17. Mixed with calcium carbonate, the ratios become 57:12:16 and 44:0:42 respectively.

These soils exhibit a great variation in their action towards ammonium sulphate and cotton-seed meal, and this even under conditions made favorable by the addition of calcium carbonate. Some of the soils nitrify ammonium sulphate more rapidly than cotton-seed meal; others nitrify a greater percentage of the nitrogen in cotton-seed meal during the same period. We also have a soil which does not nitrify cotton-seed meal, but nitrifies ammonium sulphate.

Such variations as these are exactly what we expected to find.

EFFECT OF INCREASING THE RATIO OF SOIL TO FERTILIZER.

The main series of experiments was carried out with a mixture containing 0.3 gram nitrogen to 500-gram soil. Some other experiments were conducted with half this quantity of nitrogen to the same amount of soil. The general result of dilution is to increase the quantity of nitrates formed; though this is not always the case. It is possible for the *percentage* nitrified to be increased under such conditions, though the actual *amount* of nitrates formed is less. This is illustrated by soil 1667; the percentage of nitrification in the soil with full and with half quantities of nitrogen is as 57:72, but the actual amount of nitrates formed are as 57:36.

DISCUSSION OF RESULTS.

We will now consider the bearing of these experiments on the explanations previously put forward.

(1) Ammonium sulphate may hinder the action of the nitrifying organisms.

Additional evidence in favor of this hypothesis is afforded by the fact that the progress of the nitrification is more rapid when the quantity of ammonium sulphate is reduced.

The organisms seem to thrive more vigorously when less ammonium sulphate is present. In two cases a decrease in the quantity of ammonium sulphate had no effect, but very little nitrification took place in these soils.

Again, supporting this hypothesis, is the fact that less nitrification takes place when ammonium sulphate and cotton-seed meal are mixed than with either separate.

This hypothesis can not explain, however, why ammonium sulphate is nitrified to a greater extent than cotton-seed meal in one soil, and to a less extent in another.

(2) The nitric and sulphuric acids formed are detrimental to the nitrifying organisms, being neutralized only in part by the bases of the soil. It is a well known fact that the organisms which nitrify ammonium salts to nitrous acid thrive best in a medium that is slightly alkaline. This explanation has been generally accepted for a long time and requires little discussion.

(3) "The third explanation is, that different soils contain different nitrifying organisms, some of which convert organic matter directly to nitrates, while others change ammonium salts to nitrates more readily." If this explanation is justified, we may expect to find soils in which ammonium sulphate is nitrified to a greater extent than cotton-seed meal, and others in which the cotton-seed meal is nitrified to a greater extent. This is exactly what we have found. In soils 1667, 1668, 1670 and 1676 the ammonium sulphate is nitrified more rapidly than the cotton-seed meal, in the presence of calcium carbonate, while in soils 1669, 1677 and 1679 the contrary is the case. In soil 1669, 41.5 per cent of the nitrogen in cotton-seed meal is nitrified, and only 15.8 per cent of that in ammonium sulphate; in soil 1679 3 per cent for ammonium sulphate, and 10.6 per cent for cotton-seed meal.

The experiments here recorded seem to justify the preceding explanations.

THE NITRIFYING ORGANISMS.

The prevailing view in regard to the conversion of organic nitrogen to nitrites seems to be that the organic matter must first be converted to ammonia, then the ammonia is converted into nitrites, and the nitrites are next changed into nitrates.

If this view is correct, then it is in opposition to the explanation we have put forward, that different soils contain different nitrifying organisms, some of which convert organic matter directly to nitrites, while others change ammonium salts to nitrites more readily.

The pure nitrous organism is capable of nitrifying organic substances, according to Warington,[1] Frankland and Stutzer. On obtaining the organism in a pure state, experiments were at once started by Warington in solutions containing urea, urine, asparagine and milk, with suitable organic salts. Out of the 8 asparagine solutions 7 showed very distinct nitrification; of the 8 milk solutions 5 showed distinct nitrification; of the 8 urine solutions 6 showed decided nitrification, and of the 8 urea solutions 3 nitrified.

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[1] Jour. Chem. Soc., 59, 507 (1891).

"These experiments should be regarded as preliminary only, as the course of nitrification has not been studied, or any quantitative experiments made. That the pure nitrous organism can attack nitrogenous organic bodies is, I think, fully proved. The nitrification has, however, been especially in the case of asparagine and milk solutions, decidedly sluggish. The contaminated milk culture has nitrified to a greater extent than the corresponding pure culture. It is quite possible, therefore, that other organisms may render considerable service in the process of nitrification, by making a preliminary attack upon organic matter."

On the other hand, V. Omelianski[1] has made a number of experiments, and concludes that pure cultures of nitrifying bacteria are incapable of nitrifying organic nitrogen. Nitrogen in this form must first be converted into ammonia by the action of other micro-organisms before the nitrifying organisms can utilize it. It is claimed that the opposite conclusions reached by Frankland, Warington and Stutzer and his associates were based upon inaccurate observations.

It is possible that Warington and the others are wrong, and that the pure nitrous organism can not nitrify organic nitrogen. It is also possible that the organism isolated by Warington is different from the one isolated by Omelianski. At any rate, it is impossible to assert with certainty that the nitrous organism can not nitrify organic matter.

It would not be surprising, however, if the nitrous does *not* nitrify organic nitrogen. The conditions under which it is separated from other organisms and a pure culture prepared are favorable to the development of an organism which nitrifies ammonium salts, and any organism which can not oxidize inorganic nitrogen, and can not grow in such a solution, is necessarily excluded. The method of Winogrodski as used by Omelianski[2] consists in first growing the organism in a solution of ammonium sulphate, sodium chloride, potassium phosphate, magnesium sulphate, and iron sulphate in water, to which magnesium carbonate is added, for three or four generations, and finally in a similar mixture in gelatinous silicic acid. Such a medium is unfavorable for the development of the nitrate batcerium (which oxidizes nitrites to nitrates), and if the organisms developed in it do not oxidize organic nitrogen to nitrites, it is no evidence that organisms which have that power do not exist.

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[1] Exp. Sta. Record 12, 115 abs. (1901).

[2] Central-Blatt of Agr. Chem., 29, 565 (1900), abs.

The nitrifying bacteria of Frankland and of Warington were also separated by growth in an inorganic medium.

It has been found that the nitrifying organisms will not grow on gelatine. Of over a hundred species of bacteria separated by culture on gelatine, not one has been certainly found to possess the power of nitrifying. Some other medium than gelatine must be used.

It is believed that there are different species of nitrifying bacteria. In attenuated cultures from soils from different parts of the world Winogrodski[1] observed several kinds of microbes, some of which were isolated, and were found to retain under culture their power of oxidizing ammonia, but to lose after a few generations the power ot oxidizing nitrites. It is probable that the nitrous organisms constitute a group, of which each soil contains a particular species.

According to E. Chuard,[1] nitrification in turf earth differs essentially from that taking place in arable soils. The addition of chalk, potassium carbonate, or calcium sulphate exerts a retarding action on the nitrifying process. Whether the difference is due to the action of a different organism, or whether the process of nitrification is different from that obtaining in arable soils has not yet been determined.

SUMMARY.

(1) Calcium carbonate exerts a decided accelerating influence upon the nitrification of cotton-seed meal and ammonium sulphate, especially the latter.

(2) In some soils a greater percentage of nitrogen is nitrified in the form of ammonium sulphate than in cotton-seed meal; in other soils the contrary is the case, even in the presence of calcium carbonate. Other soils exhibited little nitrifying power, under the conditions of the experiments.

(3) Three of the factors which produce this result are probably as follows:

(a) The presence of ammonium sulphate may hinder the action of the nitrifying organisms.

(b) The acids formed may be a hindrance when no base is present to neutralize them.

(c) Different soils may contain different classes of nitrifying organisms, some of which oxidize ammonium salts more readily, while others prefer organic compounds.

(4) We have found no evidence on record tending to show that organisms do not exist in the soil which nitrify organic compounds directly. It has been show that gelatine and agar-agar are unsuitable mediums for the growth of nitrifying bacteria. All nitrous bacteria heretofore described have been grown in inorganic mediums, which

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[1] Jour. Chem. So. (abs.), 60, 1545 (1891).

would be essentially unfavorable to organisms which prefer organic compounds to ammonium salts.

(5) Whatever the explanation, the fact that different soils behave differently toward ammonium sulphate and cotton-seed meal, is of considerable scientific and practical importance.

This work will be continued.

ACKNOWLEDGMENT.

The authors wish to make acknowledgment to Director H. J. Wheeler, of Rhode Island; Chemist H. K. Miller, of Florida; Agriculturist W. P. Brooks, of Massachusetts, and State Chemist B. W. Kilgore, of North Carolina, for their kindness in furnishing us with samples of soil; and to Dr. F. L. Stevens, Professor of Biology, in this college, for his kindness in reading the manuscript.

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The Determination of Sulphur in Plants.*

By G. S. FRAPS, Ph.D., Assistant Chemist.

In a previous paper[1] the author called attention to the loss of sulphur in preparing ash of plants. The conclusion reached was that "the sulphur obtained when the ash was burned by itself is from 4 to 100 per cent less than when burned with calcium acetate. Whether the calcium acetate retains all the sulphur or not, is a point which requires further study." The facts which will be presented here show that the calcium acetate does not retain all the sulphur.

The object of the work was to compare the calcium acetate method with some method by the use of which we could be reasonably certain that all the sulphur contained in the plant in inorganic or organic combination would be retained and determined. A great difficulty is that a very small amount of sulphur is contained in a large quantity of plant material. The Liebig method (fusion with potassium hydroxide and a small amount of potassium nitrate in a silver dish) and the Carius method (heating in a sealed tube with fuming nitric acid) were considered, but offered difficulties on account of the large quantity of organic material to be handled. The following method was finally adopted for trial:

Fifteen grams material were placed in a flat porcelain dish of about 250 c. c. capacity, 35 c. c. of nitric acid (conc.) added, and the mixture heated gently until the action had moderated. One gram potassium nitrate was then added, and the mixture evaporated to a thin paste, transferred to a platinum dish, evaporated on a water-bath, and ignited to an ash. After heating for some time, the ash was dissolved in dilute hydrochloric acid, the solution evaporated to dryness, and the residue dried thoroughly to render silicia insoluble. It was moistened with a little dilute hydrochloric acid, evaporated, and again dried. The residue was moistened with about 5 c. c. of hydrochloric acid, taken up with about 50 c. c. of boiling water, filtered and sulphuric acid determined in the filtrate by the usual method.

A blank determination with the reagents proved them to be free from sulphur. The sulphur (as sulphur trioxide) found by this method compared with the others is given in the following table:

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[1] Jo. Am. Chm. Soc. 23, 199 (1901).

*This article appeared in the April number of the Journal of the American Chemical Society [24, 346 (1902)].

SULPHUR TRIOXIDE IN PLANT (AIR-DRY)

	In ash (usual way). Per cent.	In calcium acetate ash. Per cent.	Nitric acid method. Per cent.
Wheat bran		0.221	0.368
Cotton-seed meal		0.343	0.926
Green rape	1.02	1.25	1.63
Wheat bran	0.00	0.14	0.30
Corn silage	0.20	0.24	0.43
Timothy hay	0.15	0.17	0.28

It is evident that the calcium acetate method does not give correct values for sulphur.

It is not believed that the loss of sulphur is due to volatilization of *sulphates,* but to the escape of organic sulphur compounds which are not burned or oxidized. Most of the sulphur in a plant is not in the form of sulphates, but is in an organic form, and it is not surprising that it is lost under the conditions. The same would be true of *chlorine,* which is probably much more difficult to retain than sulphur.

The following modification of the nitric acid method just described has been found more convenient. It calls for the use of a smaller quantity of material, and leaves out the platinum dish, which is liable to be damaged under certain conditions.

Five grams material are placed in a 3½ inch porcelain evaporating dish, 20 c. c. of concentrated nitric acid added, and the mixture heated cautiously on the water-bath until all danger of overflowing has passed. It is then partly evaporated, 10 c. c. of a 5 per cent solution of potassium nitrate added, the mixture evaporated to dryness and ignited, at first gently, then under a blast-lamp, until the residue is white. It is then dissolved in hydrochloric acid, evaporated to dryness, and heated for some time in an air-bath to render silica insoluble. The residue is taken up in water with the addition of a little acid, filtered, and the sulphuric acid precipitated with barium chloride, etc., in the usual way. (This method was adopted as a provisional method by the Association of Official Agricultural Chemists, November, 1901).

Since the preceding article was written, it has been found more desirable to use calcium acetate in place of potassium nitrate. With it the ash does not fuse, and is very much more easily burned free from carbon.

The Determination of Sulphur and Chlorine in Plants.

BY G. S. FRAPS, PH.D., ASSISTANT CHEMIST.

The preceding article contains an account of the work on the determination of sulphur which was done up to last November. The study of the methods of determining sulphur has since been continued, and results of the study are given in this article. The determination of chlorine in plants was also undertaken, with the results to be described later on in this paper.

METHODS FOR SULPHUR STUDIED.

The following methods for the determination of the total sulphur in plants were tested:

(1) *Nitric Acid Method.*—Five grams material is placed in a 3 1-2 inch porcelain evaporating dish, 20 cc. of nitric acid (conc.) added, and the mixture heated cautiously on the water-bath until all danger of overflowing has passed. It is then evaporated partly, 10 cc. of a 5 per cent solution of potassium nitrate added, the mixture evaporated to complete dryness, and ignited, at first gently, then under a blast lamp until the residue is white. It is then dissolved in hydrochloric acid, evaporated to dryness, and heated for some time in an air-bath to render silica insoluble. The residue is taken up in water with the addition of a little acid, filtered, and the sulphuric acid precipitated with barium chloride in the usual way.

As has been stated in the preceding article, this method gives good results. It has a disadvantage, however, in that the ash produced is easily fusible, acts upon the porcelain dish, and is ignited free of carbon with great difficulty. It was to overcome this objection that the modification described below was tested.

(2) *Nitric Acid Method Modified.*—The modification consists in the use of a solution of calcium acetate containing 0.56 gm. CaO., in place of the 20 cc. of potassium nitrate solution. The ignition takes place much more easily, the ash does not fuse, and is more easily burned free of carbon than when potassium nitrate is used.

(3) *Boiling with Nitric Acid.*—An attempt was made to destroy the organic matter by boiling the material with nitric acid, which, I understand, is the method used for meats in the nutrition investigations of the Office of Experiment Stations. The method did not succeed with vegetable materials. Several experiments were made, but in no case was all organic matter of the vegetable materials destroyed,

even when 5 grams material was boiled to dryness with 100 cc. nitric acid, in a kjeldahl flask. As it would, therefore, be necessary to wash the residue from the flask into a dish, and ignite with the addition of potassium nitrate or calcium acetate, to remove organic matter, this method would differ from the two preceding only in that a larger quantity of acid is used, and the digestion with the acid is more prolonged. The method was not further examined.

(4) *Fusion with Caustic Soda.*—This is the standard method for determining sulphur in non-volatile organic compounds. The method as tested was as follows:

Five grams material in a nickel crucible was saturated with 40 cc. of a solution of 150 grams sodium hydroxide in 300 cc. water, evaporated to dryness, and fused with the addition of a little sodium peroxide. The fusion requires care to prevent the material from overflowing the dish, and the whole process is somewhat long. The melt was dissolved in water, neutralized and acidified with hydrochloric acid, evaporated to dryness and heated to render silica insoluble, filtered, and the sulphuric acid precipitated from the filtrate, the volume of which was about 200 cc. The sodium hydroxide and sodium peroxide contained a large quantity of sulphates—about 0.1 gram in the quantity used in the determination was found in the blank determination. The results with this method are decidedly low. The low results may possibly be due to the solubility of barium sulphate in sodium chloride, about 38 grams of the latter salt being present in the solution from which the barium sulphate was precipitated, or it may be due to the error caused by impurities in the reagents.

(5) *Eschka's Method.*—This is the method usually used for the determination of sulphur in coals. As applied to plant materials it was as follows:

Five grams material was intimately mixed, in a platinum dish, with 7½ grams of a mixture of 2 parts magnesium oxide to one of dried sodium carbonate. The mixture was heated, stirring frequently, and the temperature raised slowly until all carbon appeared to be burned off. The mass was transferred to a beaker with about 50 cc. water, 150 cc. of saturated bromine water added, and boiled five minutes. It was allowed to settle, decanted through a filter, boiled a second and a third time with about 30 cc. water, and washed thoroughly. The filtrate was made acid with hydrochloric acid, boiled until bromine was expelled, and then precipitated with barium chloride in the usual way.

The results by Eschka's method were too low.

RESULTS OF WORK.

The analytical results by the different methods are given in the following table (Table 1). The figures in each case are corrected for the sulphur in the reagents, found by a blank determination. The blank was very low in the case of the two nitric acid methods; in the Eschka method it was equivalent to 0.0058 gram barium sulphate in the quantity of the reagents used for each test. As has already been stated, the fusion method gave results much too low, and the blank was high, being 0.1103 gram barium sulphate.

TABLE I.

PERCENTAGE OF TOTAL SULPHUR (AS SO_3) BY DIFFERENT METHODS.

	Nitric Acid Method.	Nitric Acid Modified.	Eschka Method.
Corn	0.249	0.287	0.238
	0.244	0.286	0.208
Mean	0.247	0.287	0.223
Peas	0.481	0.480	0.297
	0.533		0.312
	0.503		0.313
Mean	0.518	0.480	0.307
Millet	0.369	0.427	0.451
	0.376	0.434	0.460
	0.400		
Mean	0.382	0.431	0.456

The results of this study may be summarized as follows:

(1) The nitric acid method, modified by the use of calcium acetate in place of potassium nitrate, is decided to be the best method.

(2) Eschka's method gave low results.

(3) Fusion, with caustic soda as here described, gives low results. It is a very tedious operation.

DETERMINATION OF CHLORINE.

The writer has already called attention to the fact that chlorine, as well as sulphur, will be lost in burning plant substance to an ash by itself. It will appear later that the loss is due to decomposition of the chlorides by the heated organic matter.

LOSS OF CHLORINE.

Chlorine was determined in a number of substances in two ways, namely, in the ash as prepared in the usual way, and by fusion of the plant material with sodium hydroxide, a method which will be described in full later on in this paper.

The results of the determination are as follows (Table 2):

TABLE II.

PERCENTAGE OF CHLORINE IN PLANTS.

	Ash Method.	NaOH Method.
Corn	trace	0.040
Peas	0.005	0.008
Peas, No. 2	0.001	0.012
Oats	0.005	0.097
Oats, No. 2	0.001	0.056
Peanuts	0.008	0.017
Cotton seed meal	0.008	0.032
Cotton seed hulls	0.005	0.013
Linseed meal	0.010	0.029
Millet	0.120	0.187
Corn silage, dry	0.310	0.607
Green rape, dry	1.261	1.290
Green peas, dry	0.160	0.205
Sweet potatoes, dry	0.341	0.362
Timothy hay	0.864	0.888

It is evident that a considerable proportion of the chlorine in plants may be lost in burning them to an ash, particularly when there is only a small quantity of chlorine present in the plant.

The cause of the loss is shown by the work of Davies, reported in the Journal of the Society of Chemical Industry, 20, 98. (1901). He experienced similar losses when sugar, starch or filter paper was ignited with sodium chloride. The alkalinity of the ash was evidence that no base had been lost, and if the sodium chloride was added after the sugar had been charred, and the ignition then completed, no loss took place. That is to say, the loss took place during the initial stages of the combustion, and not during the time the carbon was being burned off, and was probably due to the decomposition of the chlorides by the hot vapors from the organic matter. Extracting the material with hot water after charring, and then completing the combustion, can therefore have no effect on the loss of chlorine, since it takes place before the extraction. When sodium carbonate equivalent to five per cent of the organic matter was added to the material, the loss of chlorine was prevented.

DETERMINATION OF CHLORINE IN PLANTS.

Three methods for the determination of chlorine in plants were tested.

(1) *Ignition of the Material with Calcium Acetate.*—Five grams substance was moistened with 20 cc. of a solution of calcium acetate containing 0.56 gram calcium oxide, evaporated to dryness, and ignited. The ash was dissolved in nitric acid, filtered and chlorine determined in the filtrate by the Volhard method. On account of the very small quantity of chlorine present in many of the substances, a gravimetric method could not be used as the precipitate would not coagulate. The results by this method are low (Table III).

(2) *Fusion with Sodium Hydroxide.*—Five grams substance was mixed thoroughly with 10 cc. of a solution of grams caustic soda in 200 cc. water, evaporated to dryness, and finally fused. A nickel crucible was used for a portion of the work, silver crucibles for the remainder, due care being taken to prevent the silver from being detached from the crucible. It is better to use nickel crucibles, as there is always a little danger of small particles of silver being detached. The melt was dissolved in water, neutralized with nitric acid, filtered, and chlorine determined in the filtrate by the Volhard method.

The method yields satisfactory results, but it is long, and the crucibles wear out rapidly. (Results in Table III).

(3) *Ignition with Sodium Carbonate.*—Five grams substance in a platinum dish is impregnated with 20 c. c. of a 5 per cent solution of sodium carbonate, evaporated to dryness, and ignited as thoroughly as possible. The residue is extracted with hot water, filtered and washed. It is returned to the platinum dish, ignited to an ash, dissolved in nitric acid, and filtered into the previous filtrate. This is made acid with nitric acid, and the chlorine determined by the Volhard method.

In one or two cases, the filtrate from the first extraction was yellow from organic matter. It was returned to the dish with the charred residue, evaporated to dryness, and ignited. The residue burned very readily to a white ash.

This method is recommended.

RESULTS OF WORK.

The results by the three methods are contained in Table III:

TABLE III.

Percentage of Chlorine in Plants

	Calcium Acetate Method.	Caustic Soda Method.	Sodium Carb. Method
Corn	0.0021	0.040	0.027
		0.040	0.026
Millet	0.148	0.165	0.188
		0.171	0.194
		0.204	
		0.206	
		0.187	0.191
Corn silage	0.400	0.616	0.610
		0.599	
Cotton seed meal	0.031	0.032	0.020
Cotton seed hulls	0.010	0.013	0.017
Green peas	0.215	0.197	0.228
		0.212	0.230
Oats	0.034	0.056	
Timothy hay	0.870	0.914	0.897
		0.878	0.911
		0.872	
		0.888	0.905

The sodium carbonate method gives as accurate results as the method of fusion with caustic soda, and as it is shorter and easier, it is to be recommended for use.

SUMMARY OF RESULTS.

(1) The nitric acid method, modified by the use of calcium acetate in place of potassium nitrate, is to be recommended for the determination of total sulphur in plants.

(2) Eschka's method, and the method of fusion with caustic soda and sodium peroxide as described in this paper, gives low results. Boiling with nitric acid in a kjeldahl flask is not to be recommended.

(3) Loss of chlorine takes place in the ignition of plant materials to ash, probably due to decomposition of chlorides, and not to their volitilization.

(4) The method of igniting the material with sodium carbonate is recommended for the determination of chlorine in plants. (This method was adopted as a provisional method by the Association of Official Agricultural Chemists, October, 1902).

Since this paper was written, Dr. H. C. Shermon has published results which show that the nitric acid method, described in the above paper, gives low results.

The Solubility of Barium Sulphate in Ferric Chloride, Aluminium Chloride, and Magnesium Chloride.*

By G. S. FRAPS, Ph.D., Assistant Chemist.

In working on the determination of sulphuric acid in soils, Mr. C. B. Williams, Assistant Chemist to the North Carolina Department of Agriculture, found that considerably more barium sulphate was obtained when the iron and aluminium had been previously precipitated from the soil solution.[1] This led to the following work.

The latest determinations of the solubility of barium sulphate which have been made are those of R. Fresenius and E. Hintz,[2] in which the solubility was determined in pure water, 2.5 and 10 per cent ammonium chloride, 2.5 per cent sodium chloride, 10 per cent nitric acid, and 10 per cent hydrochloric acid, alone, and in the presence of an excess of sulphuric acid or barium chloride.

In regard to the effect of ferric salts, aluminium salts, and magnesium salts upon its solubility, we have few data. Fresenius states that its solubility in water is increased by the presence of magnesium chloride, and Lunge[3] states that it is soluble in ferric chloride. As the precipation of barium sulphate sometimes takes place in the presence of these salts, the knowledge of its solubility is important in analytical work.

METHOD OF WORK.

The method used was similar to that adopted by R. Fresenius,[4] barium chloride being used in place of barium hydroxide.

A solution of barium chloride was prepared, 100 cc. of which was found to give 0.0952 and 0.0945 gram barium sulphate, *i. e.*, 1 cc. = 0.95 milligram $BaSO_4$ A solution of sulphuric acid was prepared, 100 cc. of which gave 0.1206 and 0.1204 gram barium sulphate, or 1 cc. = 1.2 milligrams barium sulphate.

Preliminary tests were then made upon solutions of ferric chloride, aluminium chloride, and magnesium chloride. Four hundred cc. of the solutions were placed in precipitating jars and sulphuric acid and barium chloride solution were added in the proper proportions to make 10 milligrams barium sulphate. The solution was allowed to stand twenty-four hours, and if no precipitate appeared

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[1] His results are not yet published.

[2] Ztschr. anal. Chem., 35, 170 (1896).

[3] Ibid., 19, 431.

[4] Loc. cit.

* This article appeared also in the American Chemical Journal [27, 288 (1902)].

10 milligrams more of barium sulphate were added, and so on until a precipitate appeared.

More exact tests were then made, based upon the results of the preliminary tests. In making these tests, the solution was allowed to stand forty-eight hours instead of twenty-four, as it was found that precipitates sometimes appeared during the second twenty-four hours. Much smaller quantities of barium sulphate were added each time, and the very faintest trace of appearance of barium sulphate was watched for. It was found that if the stirring-rod was rubbed against the sides of the vessel the barium sulphate separated out at this point more rapidly and more readily than elsewhere, and could be easily seen. In making up the solutions of the various salts, allowance was made for the quantity of water which would probably be added with the barium chloride and sulphuric acid.

RESULTS OF WORK.

The solubility of nascent barium sulphate in the solution of chlorides of different concentrations is given in the following table. Neither barium chloride nor sulphuric acid was present in excess in any case.

SOLUBILITY OF BARIUM SULPHATE.

Amount of salt per liter. Grams.	Milligrams $BaSO_4$ dissolved per liter.		
	$FeCl_3$.	$AlCl_3$.	$MgCl_2$.
1	58	33	30
2½	72	43	30
5	115	60	33
10	123	94	33
25	150	116	50
50	160	170	50
100	170	175	50

Comparing these figures with the results of Fresenius with other salts, we find that barium sulphate is much less soluble in 10 per cent ferric chloride, or aluminium chloride, than in 10 per cent nitric acid, or hydrochloric acid. It is also more readily soluble in a 10 per cent solution of ammonium chloride than in ferric chloride or aluminium chloride, of the same strength, though less soluble in 2.5 per cent ammonium chloride.

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SOLUBILITY IN PRESENCE OF BARIUM CHLORIDE.

The solubility of barium sulphate in ferric chloride and aluminium chloride in the presence of barium chloride in excess was tested in the same way as before. The results are as follows. In each case 12.5 milligrams barium sulphate per liter were present (5 milligrams in 400 c. c.):

With 5 grams aluminium chloride and 7.5 c. c. of barium chloride (1 : 10) per liter present, the solution became turbid in an hour.

With 10 grams aluminium chloride and 20 c. c. barium chloride the solution became turbid in an hour.

With 25 grams aluminium chloride and 12.5 c. c. barium chloride a very faint precipitate appeared in forty-eight hours.

With 5 grams ferric chloride, 7.5 c. c. barium chloride, a slight precipitate appeared in twenty-four hours.

With 10 grams ferric chloride, 20 c. c. barium chloride, a slight precipitate appeared in twenty-four hours.

With 25 grams ferric chloride and 12.5 c. c. barium chloride, a very faint precipitate appeared in forty-eight hours.

Comparing these results with those of Fresenius, we find that, in the presence of barium chloride, barium sulphate is less soluble in ferric chloride, or aluminium chloride, than in a 10 per cent, or 2.5 per cent, solution of ammonium chloride, or in a 2.5 per cent solution of sodium chloride, or nitric acid, or hydrochloric acid.

It must be remembered that all these tests were made at the temperature of the laboratory. The results might have been somewhat different had the work been carried on at the temperature usually used for the precipitation of barium sulphate.

The Sulphur Content of Some Vegetable Materials.

BY W. A. WITHERS. A. M., CHEMIST, AND G. S. FRAPS, PH. D., ASSISTANT CHEMIST.

It has been assumed by most writers and workers in agricultural chemistry, that the ash of a plant contains all the sulphur and chlorine of the plant, and numerous calculations have been based upon this assumption, in spite of the fact that from time to time work has been published tending to show that this assumption is erroneous. Recent articles by one of us[1] prove that the sulphur content of an ash is no indication whatsoever of the amount of sulphur in a plant. This point needs to be emphasized until it is clearly recognized and generally accepted. Determinations of sulphur (and of chlorine) in ashes, so far as they are considered to throw any light upon the composition of the plant, have no value at all, and may as well be discarded. Unknown quantities of sulphur and chlorine have been volatilized, and what is left behind bears no relation to what was in the plant.

Inasmuch as the sulphur content of plants has been generally under-estimated, it becomes a matter of some importance to ascertain the amount which is really present. This is the object of the present paper; we will communicate the results of the determination of the true sulphur content of certain vegetable materials.

The method used for determinating total sulphur is that described in a recent article[2] by one of us, using equal parts of calcium acetate and potassium nitrate, however, instead of potassium nitrate alone. The ash is more easily burned completely in this case.

COTTON-SEED MEAL.

Ten samples of cotton-seed meal, from different sources, were analyzed. One sample was from Sea Island seed, and contained a large quantity of hulls. It is excluded from the average.

The results for the nine samples are as follows: (For individual analyses see tables at end of this article).

	S (as SO_3) in Meal.
Average	1.10
Maximum	1.30
Minimum	0.92
Sea Island	0.63

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[1] See preceding articles in this Report.
Jour. Am. Ch. Soc., 123, 19 (1901); 24, 346 (1902).

[2] This Report, and Jour. Am. Ch. Soc., 24, 346 (1902).

The fertilizing constituents of cotton-seed meal, as calculated from 204 analyses of the ash, are as follows:[1]

	Phosphoric Acid.	Potash.	Soda.	Lime.	Magnesia.	Sulphuric Acid.
Average	2.88	1.77	0.29	0.43	0.95	0.19
Maximum	4.62	3.32	0.73	1.25	1.26	0.40
Minimum	1.26	0.87	0.03	0.27	0.48	0.07

According to the above table, the meal contains less sulphur (as SO_3) than phosphoric acid, potash, soda, lime or magnesia. But the ash retains, on an average, only one-sixth of the sulphur, and there is then really present in cotton-seed meal more sulphur than either soda, lime, or magnesia, and the sulphur content is not far behind the potash content.

OTHER COTTON SEED PRODUCTS.

Six samples of the hulls were analyzed, with the following results: (See tables at end).

	S (as SO_3) in hulls.
Average	0.176 per cent.
Maximum	0.292 per cent
Minimum	0.089 per cent.

The results of eight ash analyses[1] give the following constituents of the hulls:

	Phosphoric Acid.	Potash.	Soda.	Lime.	Magnesia.	Sulphuric Acid.
Average	0.25	1.02	0.02	0.18	0.26	0.08
Maximum	0.56	1.32	0.02	1.09	0.35	0.09
Minimum	0.09	0.36	0.01	0.13	0.16	0.08

In this case the ash retains nearly one-half of the sulphur. The sulphur content is not very far behind the phosphoric acid.

Two samples of cotton-seed kernels contained 0.755 and 0.720 per cent of sulphur (as SO_3), respectively.

Three samples of lint cotton contained (average) 0.135 per cent; maximum 0.155 and minimum 0.107 per cent. Calculated from the ash of one sample (containing 0.144 per cent), the percentage of sulphur as SO_3 was 0.043, or not quite one-third the true value.

---

[1] The Cotton Plant, U. S. Department of Agriculture (1896).

OATS.

Determinations of total sulphur, and sulphur in the ash, were made in six samples, with the following results: (See tables at end).

SO_3.	Total.	In Ash.
Average	0.491	0.050
Maximum	0.514	0.069
Minimum	0.447	0.014

The ash contains a little over one-tenth of the total sulphur. The average ash analysis of oats, according to Wolff, is as follows:

Phosphoric Acid	0.55 per cent.
Potash	0.42 per cent.
Soda	0.10 per cent.
Lime	0.10 per cent.
Magnesia	0.18 per cent.
Sulphuric Acid	0.04 per cent.

We find, however, that more sulphur, instead of less, is present than potash, soda, lime or magnesia.

COWPEAS.

Thirteen samples (mostly different varieties) were analyzed with the following results: (See tables at end of this article).

SO_3.	In Plant.	Calculated from SO_3 in Ash.
Average	0.466	0.076
Maximum	0.531	0.139
Minimum	0.419	0.034

The ash contains not quite one-sixth of the total sulphur.

CORN.

Eight samples of corn were examined. The ash of corn (which was tested for sulphuric acid in each case) contains only a very small amount of sulphuric acid, less than a milligramme of barium sulphate being found. A miligramme of barium sulphate corresponds to 0.0068 per cent SO_3 in the plant,

The sulphur content of the corn (grain) was:(See also tables at end of this article).

Average	0.338 per cent.
Maximum	0.389 per cent.
Minimum	0.302 per cent.

The ash contains less than a fiftieth of the total sulphur.

According to Wolff, the composition of corn is:

Phosphoric Acid	0.55 per cent.
Potash	0.33 per cent.
Soda	0.02 per cent.
Lime	0.03 per cent.
Magnesia	0.18 per cent.
Sulphur (as SO_3)	0.01 per cent.

The sulphur in corn is, however, *greater* in quantity, instead of less, than potash, soda, lime, or magnesia.

TOBACCO.

Four samples of tobacco were analyzed, with the following results:

SO_3.	In Plant.	Calculated from SO_3 in Ash.
Average	0.502	0.425
Maximum	0.650	0.587
Minimum	0.288	0.240

The ash contains 85 per cent of the total sulphur.

PEANUTS.

Three samples of peanuts, hulls and all, gave the following results:

SO_3.	In Plant.	In Ash.
Average	0.471	0.139
Maximum	0.508	0.180
Minimum	0.433	0.117

The ash contains less than a third of the total sulphur.

A sample of sweet potatoes (dry) contained 0.159 per cent sulphur as SO_3; the percentage calculated from that in the ash was 0.107. A sample of onions contained 0.264 per cent, and calculated from the ash content, the percentage is 0.115.

SUMMARY AND CONCLUSIONS.

(1) As an average of a number of analyses, we find that the ash of plants contain only a portion of the total sulphur, as follows:

Cotton-seed Meal	1-6.
Cotton-seed Hulls	1-5.
Oats	1-10.
Cowpeas	1-6.
Corn	1-50.
Peanuts	1-3.
Tobacco	4-5

(2) Plants contain much more sulphur than has hitherto been considered to be the case. Corn and oats contain more sulphur than potash, soda, lime or magnesia. It is probable that sulphur plays a more important part in plant nutrition than has been suspected.

(3) The sulphur content of an ash is no indication as to the amount of sulphur in the plant. Conclusions reached in regard to the sulphur content of a plant by ash analyses are entirely valueless.

TABLES OF ANALYSES.

SULPHUR AS (SO_3).

No.		SO_3 Per cent.	No.		SO_3 Per cent.
1646	Cottonseed Meal	0.95	1693	Cottonseed Hulls	0.172
1681	Cottonseed Meal	1.16	1694	Cottonseed Hulls	0.197
1682	Cottonseed Meal	1.22	1696	Cottonseed Hulls	0.089
1683	Cottonseed Meal	1.30	1697	Cottonseed Hulls	0.292
1684	Cottonseed Meal	1.08		Maximum	0.292
1685	Cottonseed Meal	1.10		Minimum	0.089
1686	Cottonseed Meal	1.06		Average	0.176
1688	Cottonseed Meal	1.10	1698	Cottonseed Kernels	0.755
1689	Cottonseed Meal	0.92	1699	Cottonseed Kernels	0.720
	Maximum	1.30	1700	Lint Cotton	0.155
	Minimum	0.92	1716	Lint Cotton	0.107
	Average	1.10	1717	Lint Cotton	0.144
	Sea Island Meal	0.63	1717	Lint Cotton in Ash	0.043
1691	Cottonseed Hulls	0.154		Average	0.135
1692	Cottonseed Hulls	0.152			

SULPHUR AS (SO_3).

No.		Total SO_3.	In Ash.	No.		Total SO_3.	In Ash.
1709	Oats	0.447	0.051	1711	Corn	0.302	Trace.
1715	Oats	0.503	0.069	1712	Corn	0.335	
1733	Oats	0.510	0.053	1729	Corn	0.301	
1734	Oats	0.514	0.062	1730	Corn	0.348	
1735	Oats	0.481	0.052	1731	Corn	0.343	
1736	Oats	0.494	0.014	1732	Corn	0.332	
	Maximum	0.514	0.69	1737	Corn	0.356	
	Minimum	0.447	0.14	1738	Corn	0.389	
	Average	0.491	0.50		Maximum	0.389	
1710	Cow Peas	0.481	0.082		Minimum	0.301	
1712	Cow Peas	0.439	0.095		Average	0.338	
1713	Cow Peas	0.487	0.139	1705	Tobacco	0.642	0.496
1718	Peas var. Greasy	0.427	0.049	1706	Tobacco	0.288	0.240
1719	Peas Red Ripper	0.462	0.054	1707	Tobacco	0.650	0.587
1720	Peas Black Eye White	0.477	0.065	1708	Tobacco	0.430	0.377
1721	Peas White Yellow Eye	0.487	0.077		Average	0.502	0.425
1722	Peas Red Crowder	0.485	0.038	1728	Sweet Potatoes	0.159	0.107
1723	Peas Lady	0.459	0.036	1739	Onions	0 264	0.115
1724	Peas Black Prolific	0.448	0.079	1740	Peanuts	0.433	0.117
1725	Peas Unknown	0.452	0.112	1741	Peanuts	0.472	0.180
1726	Peas Large Black	0.419	0.087	1742	Peanuts	0.508	0.120
1727	Peas Southdown	0.531	0.079		Average	0.471	0.139
	Maximum	0.531	0.139				
	Minimum	0.419	0.034				
	Average	0.466	0.76				

The Determination of Pentosan-Free Crude Fiber.

BY G. S. FRAPS, PH.D., ASSISTANT CHEMIST.

Until a few years ago, the only demand made upon the method of determining crude fiber, which is an entirely arbitrary method, was that the crude fiber should not contain appreciable amounts of nitrogenous compounds. A method was chosen which would give the minimum of nitrogen-content of the fiber, always considering, of course, its convenience, accuracy and adaptability to give concordant results in the hands of different analysts.

In the last few years a determination has been introduced into our scheme of analysis for foods which brings us to the necessity of making further demands upon our crude fiber determination. The introduction of the pentosan determination compels us to require of the crude fiber, that it should not contain appreciable quantities of pentosans, or else we will be obliged to make two pentosan determinations, one of total pentosans, and one of pentosans in the crude fiber.

Applying this requirement to the official method for the determination of crude fiber, we find it lacking; the crude fiber obtained contains pentosans, often in considerable quantity. The following figures are quoted from a great many available:

TABLE I.

PENTOSANS IN 100 PARTS CRUDE FIBER.

Bulletin 172, N. C. Station (1900):	
Timothy hay, No. II	14.4
Crabgrass hay, No. II	13.4
Green rape, No. I	7.7
Rice bran	8.3
J. Konig, Analyst *23*, 47 (1898):	
Rye straw	18.4
Pea straw	15.0
Clover hay	12.7
Wheat bran	2.6

We have, then, two alternatives; to adhere to this method, and determine pentosans in the crude fiber when necessary, or to seek for a new method, by which a pentosan-free crude fiber is produced.

KÖNIG'S METHOD.

In a paper read before the Association of Official Agricultural Chemists, last year, the writer directed attention to the method of J. Konig for determining pentosan-free crude fiber. This consists simply in heating or boiling the substance with glycerol containing sulphuric acid, and determining the weight of the residue.

For description, see Analyst 23, 47, or Exp. Station Record 9, 1021.

Kellner, Herring and Zähn (Exp. Station Record 11, 705) tested this method and decided that it was an improvement over the method at present in use.

C. Beck (Exp. Station Record 12, 611) did not come to such a favorable conclusion. He found the method to give somewhat varying results, but concluded that it may be particularly useful for fodders, but for finely ground grain feeds the other method is most reliable. He found it difficult to keep the temperature between 131-133 degrees.

König replies to Beck that it is easy to keep the temperature right if glycerol of exactly 1.229 sp. gr. is used, and if the flame is made so small that the liquid just boils, and only a few drops condense.

DESCRIPTION OF METHOD.

During the past summer, the writer has made some study of König's method, and the following is a full description of the method finally adopted:

DETERMINATION OF CRUDE FIBER.

(a) *Glycerol-Sulphuric Acid.*—Determine the specific gravity of the glycerol by means of a specific gravity balance, or pincnometer, and calculate the per cent of glycerol it contains by the following table: (A hydrometer will not give correct results for the specific gravity of glycerol.)

TABLE II.

Sp. gr. at 15.5°.	Per cent.	Sp. gr. at 15.5°.	Per cent.
1.2674	100	1.2460	92
1.2647	99	1.2433	91
1.2620	98	1.2406	91
1.2594	97	1.2380	89
1.2567	96	1.2353	88
1.2540	95	1.2327	87
1.2513	94	1.2300	86
1.2486	93		

Should the temperature not be 15.5 degrees, a correction may be made by adding 0.00058 for each degree above 15.5 degree.

Dilute the glycerol to exactly 1.229 sp. gr., and make up a solution 20 grams concentrated sulphuric acid (1.84) in a liter of glycerol.

(b) *The Determination.*—Place 3 grams substance in a 500 cc. Erlenmeyer flask, add 200 cc. of glycerol, and connect the flask with an inverted condenser, the tube of which passes only a short distance beyond the rubber stopper into the flask. Heat to boiling, and boil very gently for an hour, shaking the flask from time to time to wash down the particles which adhere to the sides of the flask. The boiling should take place in such a manner that only a few drops of water are formed in the condenser. Prepare a thin layer of asbestos in a two-inch Hirsch funnel, and on this place a perforated platinum disk. Filter the glycerol through this, using a suction pump, wash with hot water, then with alcohol, and with a mixture of equal volumes of alcohol and ether. The alcohol is necessary, not only to remove fats, but to remove certain products not soluble in water, formed by the action of the glycerol-acid upon the feeding stuff. Transfer to a platinum dish, dry, weigh, incinerate completely. The loss in weight is crude fiber.

PRECAUTIONS.

A primary necessity is to have the glycerol of the required density. A comparatively slight variation in density causes an increase or decrease in its boiling point, with corresponding decrease or increase in the quantity of crude fiber left.

On account of the nature of the glycerol, it is necessary to filter it as hot as possible and before it cools. Cold glycerol, even if diluted with water, filters with very great slowness. The method of filtration recommended is that found best after making trials of several other ways. These were:

(1) Dilution with water and filtration while hot, as recommended by Konig. Very often this filtration requires a long time, and always longer than the method recommended.

(2) Dilution with alcohol. Filtration takes place rapidly, and this method may be used in difficult cases.

No difficulty will be had with the method described after a little practice. The author has weighed out a set of samples, digested, filtered, and washed the crude fiber, in three hours.

RESULTS.

The results obtained are satisfactory. It is much easier to obtain concordant results by this method than by the official method. The following are determinations made:

TABLE III.

Crude Fiber by Konig's Method.

Timothy hay	27.40 per cent.	Timothy hay, No. 2	31.95 per cent.
do	27.65 per cent.	do	31.60 per cent.
do	27.32 per cent.	do	32.04 per cent.
Corn bran	10.09 per cent.	Sheep dung	34.33 per cent.
do	9.80 per cent.	do	33.74 per cent.
do	10.19 per cent.		
do	10.41 per cent.		

The work of König and others has shown that the crude fiber so obtained is practically free from pentosans.

It must be observed that the method does not seem applicable to cotton-seed meal. Two or three times as much apparent crude fiber is obtained as there should be.

Some determinations were made with this method by Mr. W. F. Pate, a graduate student. The glycerol he used was a little more concentrated, and he boiled the mixture more vigorously. The results obtained by him were 3.5 to 4.9 per cent lower.

Although these results do not appear favorable to the method, it is believed that a comparison of it with the official method will show that the one method gives, in the hands of different analysts, as concordant results as the other. This will be more particularly true when chemists have become to some extent familiar with the new method.

CONCLUSION.

The Konig method has the following advantages:

(1) It yields a fiber practically free from pentosans.

(2) It requires fewer manipulations and less time than the usual method.

This paper was read before the Association of Official Agricultural Chemists in November, 1901, and the Association adopted the recommendation that the Referee on Feeding Stuffs should undertake a study of the method.

NORTH CAROLINA AGRICULTURAL EXPERIMENT STATION.

B. W. KILGORE, Director.

PRESS BULLETIN, No. 2.

CABBAGE SNAKES.

Last year considerable was said in the press of the State in regard to cabbage snakes, especially in the cabbage sections of the western part of the State. Recently an item has been going the round of the newspapers concerning a supposed poisonous "cabbage snake" found in a head of this popular vegetable by a lady in Swain County, North Carolina. The alleged snake was sent to the North Carolina Department of Agriculture for identification, and proved to be the common and inoffensive "Hair Snake," or water worm—*gordius variabilis.*

This is not a snake but a nematode worm which during some part of its life is an intestinal parasite of the cabbage caterpillar, grasshopper and some other insects. It is often found in samples of water from shallow wells, horse-troughs and ponds. Its presence in water indicates that the water is not fit to drink, but the worm itself is not poisonous nor in any way dangerous to human beings. The popular name "Hair Snake" is given to this worm on account of its great slenderness, which has given rise to the fanciful idea that a horse hair has been transformed into a worm or "snake." Though this worm is often a foot in length it is never as thick as a knitting needle. Its color in water is usually drab, but when it lives secluded from the light it is generally white, hence the specific name, *variabilis.*

Snakes properly so-called, belong to the backbone or vertebrate series of animals; whereas the true worms belong to the backboneless or invertebrate series. We have no snakes as slender as a knitting needle, or in any way resembling a slender worm. We have no nematode worms which are visible to the unaided eye that are parasitic on human beings. Neither are they venomous or poisonous. They are, in fact, useful, in so far as they destroy noxious insects like cabbage worms and grasshoppers. Even should such a worm be left in a cabbage, cooking would render it unnoticeable, and as it is not poison no one need be afraid to handle or eat cabbage on account of the mythical "cabbage snake."

GERALD MCCARTHY, *Biologist,*
N. C. Department of Agriculture.

NOTE.—The Station will be pleased to identify further specimens, and would be glad to have any assistance or suggestions that will enable it to obtain definite information regarding cases of poisoning from "Cabbage Snakes."

NORTH CAROLINA AGRICULTURAL EXPERIMENT STATION.

B. W. KILGORE, Director.

PRESS BULLETIN, No. 3.

ANTHRACNOSE OR "BLACK-RUST" OF COTTON.

"Black-rust" of cotton bolls is each year becoming worse in the cotton fields of the eastern part of North Carolina. The damage is extensive in moist seasons. It frequently amounts to one-tenth of the crop.

"Black-rust" is a fungus disease, and the spores or germs of the fungus are usually transmitted from place to place with and in the cotton seeds. The fungus also attacks the leaves and stems of the cotton plant, but this form usually causes no appreciable damage. The spores of the fungus may, however, live over winter in the stems and diseased bolls of the preceding crop.

REMEDIES FOR "BLACK-RUST."

The simplest and most effectual remedy for this disease is the annual selection of seed from plants known to be free from the fungus. This, in connection with rotation of crops by means of which cotton will not come upon the same field oftener than once in three years, will reduce damage by "Black-rust" to an inappreciable quantity. Cotton may be sprayed like other herbaceous crops. For this crop we must use a spray which will not stain the lint. The ammoniacal carbonate of copper is the best spray to use upon cotton. This is made by dissolving six ounces of copper carbonate in three pints of strong ammonia and adding the resulting solution to fifty gallons of water. This may be sprayed on the plants by any of the garden or orchard sprayers in common use. The Bordeaux mixture may be used upon cotton while it is young, but is no better than the ammoniacal carbonate, and if used after the bolls attain full growth—and this is the time when it is most needed—the Bordeaux mixture is liable to stain the lint.

Paris green at rate of four ounces to the barrel may be used with the Bordeaux mixture to destroy caterpillars, but no arsenite can be safely used with the ammoniacal solution. But annual selection of healthy seed and rotation of crops is the best remedy for "Black-rust."

GERALD McCARTHY, *Botanist,*
N. C. Department of Agriculture.

Bulletin No. 181 May, 1902

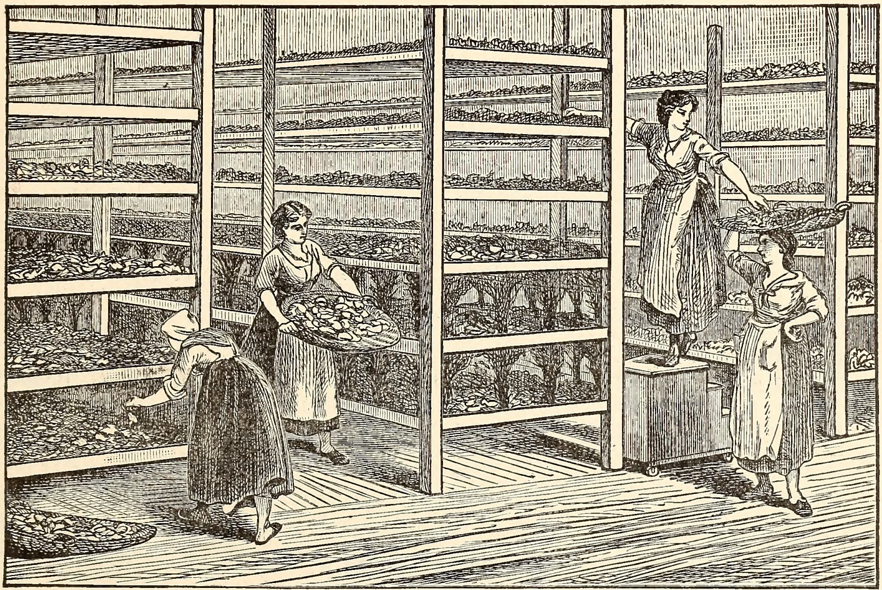
NORTH CAROLINA

Agricultural Experiment Station

OF THE

College of Agriculture and Mechanic Arts,

RALEIGH



SILK CULTURE

By GERALD McCARTHY.

Publications sent to any address in North Carolina upon application.

NORTH CAROLINA
AGRICULTURAL EXPERIMENT STATION

OF THE

COLLEGE OF AGRICULTURE AND MECHANIC ARTS

UNDER THE CONTROL OF THE

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RALEIGH, N. C.

NOTE IN REGARD TO BULLETINS OF THE EXPERIMENT STATION AND THE DEPARTMENT OF AGRICULTURE.

The present popular Bulletin on "Silk Culture" was prepared by Mr. Gerald McCarthy, Biologist of the North Carolina Department of Agriculture. An article on the same subject by him was published in the November (1901) Bulletin of the Department of Agriculture, the interest in the subject and the demand for the publication within and without the State having been so great that the first publication has been entirely exhausted, and it has been thought advisable to present the present revised edition as a Station Bulletin.

The Experiment Station and the Department of Agriculture are carrying on their work so as to aid and supplement each others' efforts. It will likely in the future, as in the present case, be advisable, occasionally, to publish the writings of the workers in one institution in the Bulletin of the other, and the results of joint investigations will be presented by the institution in the best position at the time to put them out. The Bulletin of the Department of Agriculture is published monthly, while the Station will send out its Bulletin at such times as the materials in hand justify. *Both Bulletins will go in the future to the same mailing list.*

B. W. Kilgore,
Director.

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SILK CULTURE.

BY GERALD McCARTHY, BIOLOGIST N. C. DEPARTMENT OF AGRICULTURE.

I.—HISTORY OF SILK CULTURE.

Silk, the finest and most valuable of textile fibers, is the product of a small caterpillar, the larval form of a moth, *Sericaria* (*Bombyx*) *Mori*, a native of China.

The Latin name for silk is Serica, from the ancient name of Northern China (Sericaria), where silk was first produced.

Bombyx is from the Greek word bombos—sound, referring to the booming noise made by these insects.

The modern silk-worm is in the truest sense a domesticated animal. The species in the wild state seems to have ceased to exist ages ago. There is but a single species of the cultivated silk-worm, but this species has many varieties, some of which produce white silk, some green silk, and others yellow silk. There are also very numerous cultural races—each neighborhood in old silk-growing countries having a special race, usually called after the town or province. The domestication of the silk-worm took place in China about B. C. 2700. History relates that the Emperor Hoang-Ti, of that country, had a brisk and inventive wife, by name Si-ling Chi. The Empress had, it appears, a special talent for meddling with State affairs, and became such a public nuisance that she was at last advised by her husband, in words afterwards used by Shakespeare, to "Go spin, you jade, go spin." This excellent woman, taking her lord at his word, and not finding any spinable fiber handy, went into her garden and gathered a large number of worms she saw spinning cocoons on her mulberry trees. From the fiber produced by these worms she spun with the distaff silk thread. She next invented the silk reel and method of reeling the fiber, that, with a few modifications, is in use to this day. She then improved the old wool loom and fitted it for weaving silk. On this loom, with her own imperial hands, she wove the first piece of silk cloth the world ever saw. This cloth she presented to the Emperor, who thereupon issued an edict directing all gentlewomen in China to cultivate silk-worms and to pay divine honors to the Empress Si-Ling Chi. These things are so done in China even unto this day. From the days of Si-ling Chi, silk growing has been the special occupation of women and the younger members of the household. Silk culture is to this day a household industry over the whole of China, as well as in the neighboring countries. Until the very recent introduction of cheap cottons, even the poorer classes in China were clad in silks of native production. From China, silk culture spread to India and Japan before the Christian era. Silken garments were first brought to Europe by the returning soldiers of Alexander, but the source of the fiber and the method of weaving it was not known in Europe till long after. The eggs of the silk-worm were first introduced into Europe at Constantinople during the reign of the Emperor Justinian, about the year 550 A. D. Two Nestorian monks, returning to Constantinople from China, brought samples of silken cloth, and seeds of the mulberry, which they presented to Justinian. The Emperor sent the monks back to procure eggs of the silk-worm, and to learn how to care for the worms and prepare the silk. The monks brought back with them a few hundred silk-worm eggs, hidden in a hollow bamboo staff. From these eggs are descended all the European races of silk-worms—which have brought prosperity to many nations for over 1400 years. Under the patronage of the Emperor and the instruction of the Nestorian monks, silk culture quickly took root in the Greek empire. The industry remained an imperial monopoly during the life of Justinian, but at his death became free. It soon spread through all Greece and adjacent regions. For several centuries Athens and Thebes were the chief centers of silk manufacturing in Europe.

Silk culture was first introduced into Italy at Palermo, A. D. 1146, by Greek prisoners of war, captured by Roger I, King of Naples. The Neapolitans attempted to keep the industry to themselves and monopolize the profits of the manufacture; but by the end of the thirteenth century silk-growing had been introduced into Lombardy, where it has ever since remained the chief agricultural staple.

The Saracens, by their conquests in the far East, became possessed of the secrets of silk weaving, but remained ignorant of the method of producing the fiber. They introduced the manufacture of silk into Spain and Portugal—bringing the raw material from Bagdad, to which mart silk fiber was sent from China and Persia.

Louis XI, of France, established a colony of Italian silk weavers near his Castle of Tours, but the attempt to domesticate the industry at that time failed. Subsequently silk-worms were brought from Lombardy into France in the seventeenth century, and the industry was encouraged by Henry IV, the reigning monarch. Olivier des Serres is called by Frenchmen the father of silk culture in France. It was finally established in the reign of Louis XIV, by the enlightened policy of the great French statesman, Jeane Baptiste Colbert.

Silk-worms were brought to Mexico by the monks who accompanied the army of Cortes in 1522. The greed of the Spaniard for gold, however, caused silk-growing to be soon abandoned in Spanish-America.

James I, of England, in his famous "Counter-blast against Tobacco," recommended the Virginia colonists to cultivate silk-worms instead of the poisonous weed. He further encouraged the industry by offering premiums for colonial silk, and by publishing the following lines, more remarkable, perhaps, for good sense than poetry:

> "Where silk-worms and food do naturally abound
> A gallant trade in silk must sure be found.
> Virginia excels the world in both,
> Envy and malice can gainsay this truth."

But the superior profits of tobacco and the scarcity of domestic labor prevented the honest monarch's advice from bearing fruit in colonial Virginia.

Silk-worms were brought to Carolina and Georgia by the first settlers, and the industry quickly took root. For over thirty years these two colonies exported considerable quantities of raw silk to London. A silk-reeling mill was established at Savannah in 1750. In the year 1795 over $75,000 worth of raw silk was exported from Savannah.

The Huguenots who settled in the region about Charleston, S. C., in 1677, introduced silk culture, which soon became a fashionable and lucrative amusement of the ladies of Carolina. For nearly a century from $5,000 to $10,000 worth of silk was annually exported from Charleston, in addition to what was woven and consumed at home.

From and after 1785 silk yarn in skeins and hanks was for many years the common circulating medium and standard of value in Connecticut. In 1825 three counties in that State exported $35,000 worth of silk yarn, besides what they consumed at home. About 1830 the total annual production of silk in Connecticut exceeded in value $200,000.

In 1771 Franklin and other patriots induced the people of New Jersey and Pennsylvania to take up silk growing. The native red mulberry was in these experiments used exclusively as food, for which purpose it was found to be excellent, though a little later than the white mulberry. A good deal of reeled silk was exported to London from these colonies, and was there, notwithstanding the inexperience of the cultivators, rated equal to the best Italian silk.

The early French settlers of the Illinois country, now the State of Illinois, introduced silk culture, and about 1820 a great many mulberries were planted in the Western States. But the scarcity and high price of labor prevented silk growing from becoming established in that region.

In 1826 the United States Secretary of the Treasury, Richard Rush, caused to be prepared and published a Manual of Silk Growing, which was for many years the standard American authority. Silk growing soon became very popular in all the Atlantic coast

States. From 1838 to 1844, large nurseries of the Chinese mulberry—*Morus multicaulis*—were planted, and a speculative craze set in. Yearling trees of this variety were bought and sold for $2 to $4 each. In the winter of 1841 a very severe frost destroyed hundreds of thousands of these young trees, which were now found to be not hardy above Washington. The speculation in trees collapsed. Hundreds of silk growers who had paid fancy prices for their trees were ruined. Silk growing in the United States received a set-back from which it has never recovered.

The New England silk growers, instead of planting a hardier variety of mulberry and recovering their lost fortunes, now turned to silk weaving, using imported raw silk. During the Civil War there was a tariff duty of 60 per cent *ad valorem* on imported silk cloth, whereas the reeled silk or yarn came in free. This gave an enormous stimulus to American silk manufacturing. The census of 1900 shows in operation in the United States, 483 silk mills, having a total capital of over eighty-one million dollars; an annual output valued at over one hundred and seven million dollars; 65,000 hands are employed, and over twenty million dollars is paid for labor.

Practically no American-grown silk was put upon the market in the census year 1900. The cause of the substantial extinguishment of the silk-growing industry in America will be considered in the chapter dealing with the Future of the Industry. Suffice to say here, that the decline of the industry in America is not due to climatic causes, nor to the lack of available labor, nor the lack of worms or mulberries upon which to feed them.

The world's consumption of silk is rapidly increasing, and the price of the raw material, or cocoon silk, tends constantly upwards. The possibility of increase in the old world output is slight, as the limit has been reached. This offers additional inducements to the owners of millions of acres of suitable, but unoccupied land in the new world.

The world's production of raw silk in 1895 was as follows:

Italy	8,764,800 lbs.
China	11,310,200 lbs.
Japan	6,784,800 lbs.
India	4,378,000 lbs.
France	1,971,200 lbs.
Austria	585,200 lbs.
Spain	198,000 lbs.
Greece	38,600 lbs.
Persia and Central Asia	2,268,000 lbs.
Turkey and Caucassus	185,000 lbs.
World's output	36,483,800 lbs.

II.—Classification and Natural History of Silk-Producing Insects.

The mulberry silk-worm belongs to the Natural Order of Lepidoptera, the sub-family of moths, and to the tribe Bombycides.

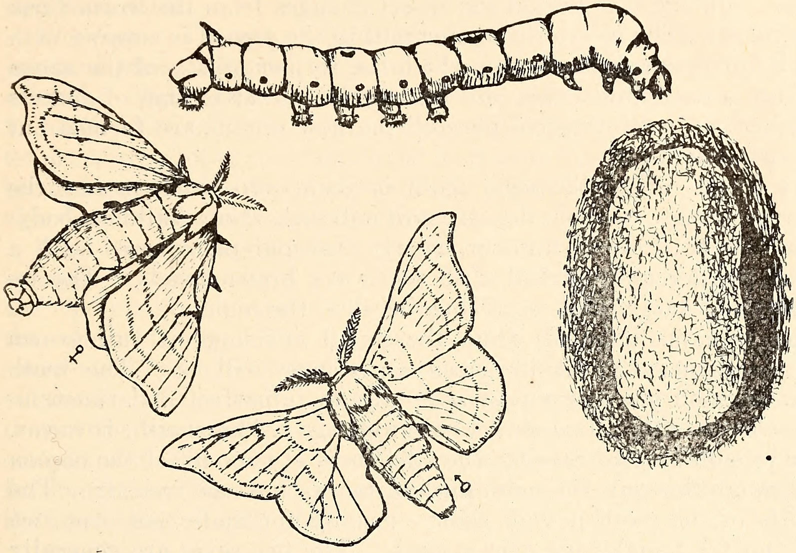

Fig. 1.—**Mulberry Silk-worm, Cocoon and Moths.** ♂ male, ♀ female

The Worm.—The silk-worm at birth weighs about one grain. Its color is normally brown at birth, but becomes darker after a few days. The body is composed of twelve separate rings or segments. Each segment, except the second, third and last, are marked on sides with two dark spots, which surround the spiracles or breathing pores. The worm has sixteen feet, of which the three pairs next to the head are true feet—the others are called "pro-legs." They are fleshy and soft like the body. On top of the next to the last segment there is a short blunt horn. The head of the worm is formed of two scaly, spherical plates, separated by a triangle. In the front part of the head are six or seven black spots. These are the eyes. Below the eyes is the mouth, armed with two toothed jaws, which move in a horizontal direction when chewing. The silk spinneretts are two in number and situated on the middle of the lower lip. The silk reservoir is within the body and extends the entire length of the body, being much doubled and twisted, so that when straightened it is over one and one-half feet long. The silk within the reservoir resembles thick mucilage.

The common annual silk-worm molts or casts its skin five times, each new skin being lighter colored than the last. The last cast is made within the completed cocoon. The casting of the skin permits the worm to grow or expand. Molting is a very laborious operation and none but healthy worms can survive it. When a worm fails to cast the skin at the proper time it soon after dies.

The Pupa.—The pupa or chrysalis stage is passed within the cocoon. During this period the insect changes from the worm form to the moth. The body of the pupa within the cocoon is covered with a hard, horny envelope, within which the former organs of the worm melt into a semi-fluid mass, and then under the attraction of centers of attraction, or "formative plates," the new organs are formed out of the pasty matter.

The Moth.—The silk-worm moth is about two inches across the outspread wings, whitish, densely covered with wooly hairs on body. The wings are four in number, nearly transparent, covered with a whitish powder and marked with two wavy brown bands. The female is much larger and more sluggish than the male.

The moth, as it comes from the pupal envelope, is full grown and as complete in all its parts as it ever will be. The moth of the common silk-worm possesses only an imperfect and functionally useless mouth. It does not eat anything. The mouth, however, serves to moisten and dissolve the silk fibers at one end of the cocoon and through this part the moth pushes its way into the free air. The free life of the moth is very short—usually for males not over two days, and for females not over a week. The two sexes are generally equal in numbers.

The Cocoon.—After the silk-worm becomes full grown it ceases to eat, diminishes in size, ejects the greater part of the contents of its alimentary tract, and seeks a retired spot among branches of trees to spin its cocoon. Having found a suitable place it first throws out numerous loose threads, forming the so-called "floss silk." Within this loose envelope it then forms the tough body of the cocoon by laying down silk threads in regular figure of eight loops. The inner side of the cocoon is lastly covered with a water and air-tight cement. About 19 per cent of the total weight of the fresh cocoon is silk. The rest is weight of chrysalis and castings. The construction of the cocoon requires about two days of unintermittent labor. The form and color of the cocoon differs considerably with different races, but with the yellow Italian races it is yellowish, oval, sometimes constricted in center, about one inch long and one-half inch in diameter. About 300 weigh one pound. Within the completed cocoon the worm takes two days to cast its skin for the last time and enter the pupal condition. The total period from the hatching of the worm to the beginning of the pupal stage is from 28 to 32 days. The pupal stage lasts from 12 to 20 days, depending upon the temperature of the surrounding air. After the moths have emerged, they dry their wings, eject a quantity of reddish liquid and flutter about until the sexes pair. Though the wings of these moths seem perfectly adapted for flight, they never attempt to fly. Copulation continues for five or six hours; the male soon after dies. The female at once begins to deposit her eggs and continues until she has laid 300 to 400. She dies soon after.

The Egg.—The egg of the common silk-worm is about the size of a mustard seed, yellowish at first, but in a few days becoming slate-colored. The eggs of the single brooded silk-worm can not be made to hatch until after several months and the seasonal variation of temperature proper to a temperate Northern climate. There are also bi-voltin or double brooded varieties, which, however, are not suitable for culture in temperate climates.

Next in value to the mulberry silk-worm we must rank the Indian species, of which there are three of prime importance. All these are "polyvoltin" or many brooded. They feed upon plants other than the mulberry. The fiber produced by the Indian worms is much coarser and stronger than that produced by the mulberry worm. The cultivation of the Indian worms need not in any way interfere with that of the common worm, since the two classes of silk will mutually complement each other, and will serve to produce mixed fabrics better for many uses than either can produce alone, thus greatly extending the usefulness of silk fiber.

THE TUSSER WORM—ANTHEREA MYLITTA.

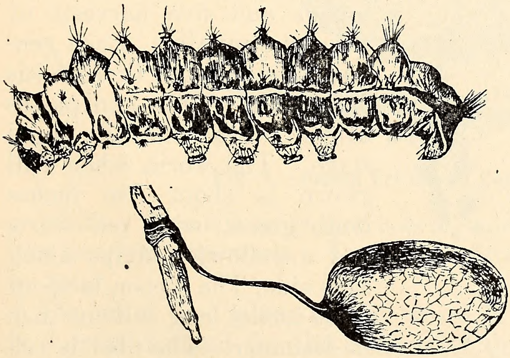

Fig. 2.—**Indian Tusser Worm and Cocoon.**

The Tusser worm belongs to the moths, and to the tribe of Attacides. This family differs from the Bombycides in forming an open cocoon, though the Tusser itself being the connecting link forms a fairly close cocoon.

The Tusser is a native of Assam, and has there been cultivated for time out of mind. The species is usually fed on trees and bushes out of doors, but may be fed wholly indoors like the mulberry worm. It is two-brooded and gives two harvests of cocoons annually. The first brood of worms hatch about June 1st from eggs kept indoors since the preceding fall. The eggs require nine days to incubate, and forty days to reach maturity. The worms molt five times. The pupal stage continues for 21 days. The first harvest of cocoons is ready about August 1st. The second harvest is ready about October 1st.

The Tusser worm when full grown is about seven inches long. The cocoon is oval, two and one-half inches long and one and one-fourth inch in diameter. The fiber is buff-colored, very coarse and strong. The cocoon not being firmly closed, the fiber is difficult to unwind, but special machinery has been invented in England for this purpose. Instead of pure water a 3 per cent solution of potash is used to macerate the cocoons.

The Tusser feeds chiefly upon shrubs of the Buckthorn family. Its favorite food is the shrub *Zizyphus jujuba,* which is with us a tender greenhouse plant, but hardy in Florida. Another species, *Zizyphus vulgaris,* is perfectly hardy south of Philadelphia, and makes an excellent hedge plant. The crape Myrtle, *Lagerstroemia Indica,* is another favorite food of this worm. This is entirely hardy south of New York. The leguminous plants, *Cassia,* sp., are eaten by this worm, as is also the castor-oil plant.

The Tusser worm is likely to be of great value in the South Atlantic, Gulf and Mississippi Valley States.

THE MUGA WORM—ANTHEREA ASSAMA.

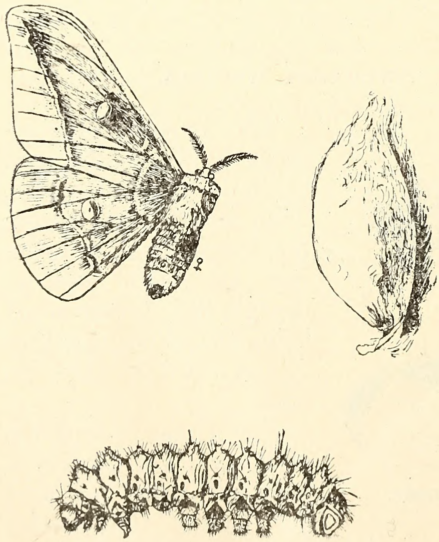

Fig. 3.—**Indian Muga Worm, Cocoon and Moth.**

The Muga worm is a sister species to the Tusser, and is a native of the same region. The Muga worm produces five broods and five harvests of cocoons annually. Each generation molts four times, feeds about thirty days, and passes fifteen days in the pupal stage. The worm when full grown is about five inches long, green, with red warts and a yellowish stripe along each side. The cocoon is about three inches long and one inch in diameter. The fiber is yellow or white. It is less coarse, reels more easily, and is more valuable than the Tusser silk. Formerly the royal robes of the kings of Assam were made of this silk.

The Muga worm feeds upon the same plants as the Tusser, and can be reared rather more easily, and in the same region. In fact, it can be profitably reared wherever the castor-oil plant thrives.

The Eri Worm—Attacus ricini.

The Eri worm is closely related to the two last-described species. It is many brooded, and usually gives five harvests of cocoons annually. The eggs incubate in 10 days; the worms feed for about 30 days, molting four times. The pupal stage lasts about 15 days. The full-grown worm is about 3 1-2 inches long, light yellow, with shades of green and white. The cocoon is oval, 1 1-2 by 1 inch. The fiber is white. The silk is rather coarse, and must be combed and spun like linen or long wools. It makes a fabric practically indestructible by wear.

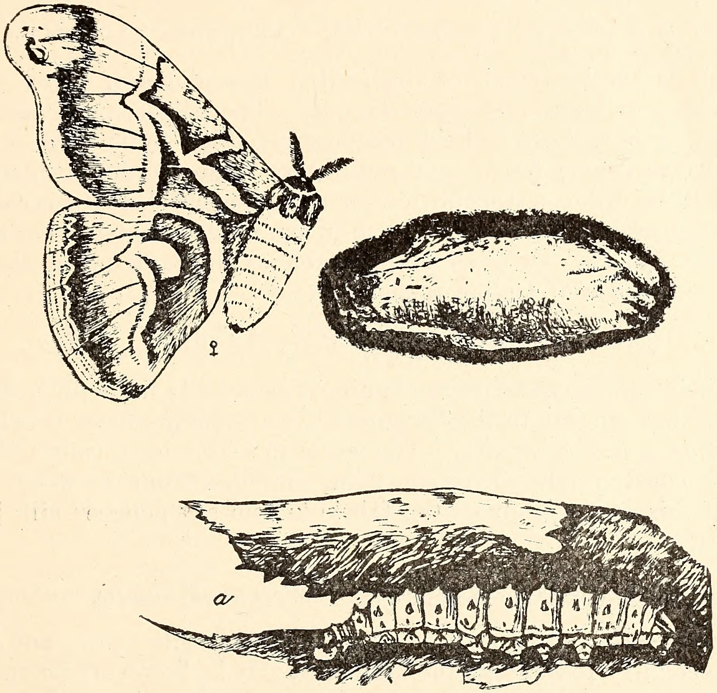

Fig. 4.—**Indian Eri Worm, Cocoon and Moth.**

The chief food plant of this worm is the castor-oil plant. There is a great demand for the cocoons of this worm in England, where special machinery has been invented for working it. The cocoons bring about 75 cents per pound.

The Eri worm offers exceptional promise for the hot alluvial soils of the Southern and Western States where the castor-oil plant flourishes.

All three of the last-named worms are more robust and less troublesome to grow than is the mulberry worm. Being many brooded, they will afford work for at least nine months in the year. The castor-oil and other plants upon which these worms feed can be so grown as to supply fresh leaves at all times when the worms require them. In rearing these Indian worms the temperatures advised for the mulberry worm must be increased about twelve degrees in every case. It must also be borne in mind that in their native home these worms are subject to almost daily deluges of rain, therefore, when reared artificially they should be daily sprinkled with water heated to about 90 degrees F., and the air of rearing room must be kept very moist.

The Japanese Tusser Worm—Antherea yama-yama.

This is another sister of the Indian Tusser worm. It is single-brooded, and feeds only upon the oak. The silk is coarse and very strong, white or green. Each cocoon gives about 1,000 yards of fiber. This worm is very hardy, and will thrive wherever the oak does, but it would be rather a difficult matter to gather oak leaves for feeding. The attempt to cultivate this worm in the United States is not recommended. It can not prove as profitable as the same labor when applied to the care of Indian worms.

The Chinese Tusser Worm—Antherea Pernyi.

This is another sister of the Indian Tusser. It feeds upon the oak and is very similar to the Japanese worm, but produces two broods and two harvests annually. The worm in China is entirely wild, the spontaneously-produced cocoons being gathered from the woods. The silk of this worm produces the fabric known as "pongee" silk in the market.

The Madagascar Silk-Worm—Brocera Madagascarensis.

This is a very close relative of the mulberry silk-worm, and in its native country feeds upon the mulberry. It is, however, far inferior to the common mulberry worm, and, therefore, merits no further attention from us.

The American Silk-Worms—Telea, Samia and Tropia.

The three genera above named are native, wild, silk-producing worms, not very closely related to the true mulberry worm. They all produce large cocoons, of coarse and poor silk. These insects feed upon our most valuable fruit and shade trees. No attempt should be made to propagate the worms artificially, as they are liable to become destructive pests.

Theophilia and *Rondetia* are two wild Chinese species of silk-worms equally as valueless as the last-named. These worms are mentioned here only to warn silk growers to beware of them, and, in fact, of all wild silk-worms, which, like the Gypsy moth, when introduced may cause wide-spread disaster.

III.—The Food of Silk-Worms.

The natural and aboriginal food of the mulberry silk-worm is the leaves of the white mulberry—*Morus alba*, and its varieties. The red and black mulberries are good, but less valuable. The so-called paper, or Otaheite mulberry, of the Southern States, is not a true mulberry, and is of little value as food for silk-worms, though they eat it well during their last age. The osage orange—*Maclura auriantica*—a tree very closely related to the mulberry, makes excellent food, but is too succulent and is liable to cause disease.

The leaves of the garden lettuce and garden scorzonera are often used as food for silk-worms. They do very well for a few days, but the worms do not thrive when fed exclusively upon these plants. The white mulberry and its varieties must always remain the standard food plant for silk-worms. Silk culture can never be made profitable where these trees do not thrive.

Botanists classify the American and European mulberries into three species, as follows:

Morus alba—Chinese or white mulberry.
Morus nigra—English or black mulberry.
Morus rubra—American or red mulberry.

In regard to the latter two species, it is sufficient to say that they are inferior to the Chinese or white species, but may be used where they abound.

The white mulberry, like all long-cultivated trees, has varied into many distinct forms, which are usually given special names.

The following varieties are considered by competent authorities to be good, and worthy of varietal names:

Morus alba, var. multicaulis. Synonyms—tartarica, indica and latifolia.
Morus alba, var. Moretti. Synonym—macrophylla.
Morus alba, var. Japonica.
Morus alba, var. Constantinopolitana.
Morus alba, var. Downingi.

1. *Morus alba.*—The white mulberry. A small tree, growing about forty feet high. Leaves ovate, thin, smooth, glossy on both sides. Acute at apex, rounded at base, toothed or lobed on edges. Leaf stalks slender. Flowers white or pinkish, in unisexual, drooping spikes, appearing in May. Fruit white or red, edible, but insipid, ripe in July. Hardy everywhere from Ontario to the Gulf, and from the Atlantic to Pacific.

2. *Morus alba. var. multicaulis.*—The Chinese mulberry. This is a smaller tree, but resembles the above species except that it has larger and thinner leaves and black fruit. It is very fine food for silk-worms, but is not hardy north of the Potomac River. It is very com-

mon in central North Carolina, dating from the speculative craze of 1840. It suckers so badly it is a nuisance in a yard.

3. *Morus alba. var. Moretti.*—Italian, or Dandelo, mulberry. This is a shrub, even less hardy than the preceding, but is excellent food for the silk-worm. It has very large leaves. The Moretti mulberry is much planted in Italy and France, where it is usually grown in form of a hedge. It is hardy in North Carolina.

4. *Morus alba. var. Downingi.*—Downing's Ever-bearing mulberry. This is a seedling of multicaulis grown by the eminent horticulturist, Charles Downing. It bears for six or eight weeks of summer edible fruit of the finest quality. As food for silk-worms it is equal to any. It makes a very beautiful shade-tree, resembling the Chinese variety. It is hardy as far north as Long Island. Does not sucker. This is the mulberry *par excellence* for the Southern silk grower. It does best planted in orchards about 20 by 20 feet. Of the other varieties of white mulberry little is known, but they are probably inferior to those herein described.

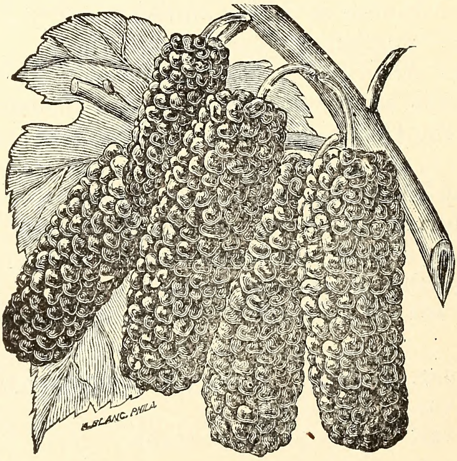
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Fig. 5.—**The Downing Mulberry.**

5. *Maclura auriantica.*—The osage orange. The osage orange is a close relative of the mulberry. It is extensively grown in the South and West as a hedge plant. It bears large and sharp thorns. This tree is rarely grown as a standard, but when it is, it makes a beautiful tree of 30 feet height, with a spread of boughs of 50 to 60 feet. It is hardy as far north as New York City. Makes good food for silk-worms, but rather succulent and in inexperienced hands is liable to cause indigestion. Not as valuable as the mulberry, but as the tree is hardier and the leaves start two weeks before those of the white mulberry, it is valuable for early feeding. It will be well to have a few trees or a short hedge of this plant on every silk-producing farm. But

no one should attempt to feed silk-worms exclusively upon the osage orange.

6. *Scorzonera hispanica.*—The oyster plant. This is a hardy perennial herb of the composite or daisy family. It is commonly grown in vegetable gardens for its root, which in shape resembles a parsnip, but tastes like a very insipid oyster. It seeds abundantly, and when cultivated it is usually sown afresh every two years. It is perfectly hardy everywhere in the United States. This plant has recently been extravagantly praised by Russian scientists as food for the silk-worm. It is claimed that the silk produced by worm fed on this plant is equal to the best, and that there is less disease among the worms and less loss by stained cocoons than when the worms are fed upon mulberry leaves. Scorzonera can be grown as an annual in any climate that produces wheat. We do not recommend scorzonera as a substitute for the mulberry, but it will be well for all silk-growers to have a small bed of this plant for early use when the mulberry may be retarded or nipped by late frosts. The leaves are cut and fed in same way as those of mulberry.

7. *Lactuca sativa.*—The garden lettuce. Lettuce leaves have often been used as a temporary food-plant for silk-worms. Any variety of lettuce will do, but those having hard and less succulent leaves should be preferred.

8. *Cannabis sativa.*—Cultivated hemp. The hemp plant is a close relative of the mulberry, and the worms will eat it, but as it is much later than the mulberry, it has little practical value in this connection.

9. *Ricinus communis.*—Castor-oil plant. As food for the Indian silk-worms, described in this BULLETIN, the castor-oil plant will be found by far the most profitable and practicable plant. In the United States this plant is a tender annual, but thrives luxuriantly on rich moist soils in the Southern and Western States. The plant is cultivated mainly for its oily seeds, from which over 600,000 gallons of oil is annually made in the Western States. The cultivation is similar to that of Indian corn. When grown mainly for silk-worm food, by taking only half the leaves, it is possible to secure a crop of oil-bearing seed as well as leaves, thus getting double toll.

10. *Cassia occidentalis and C. Marylandica.*—The Cassias belong to the legumine family of plants. The species named are both very common in the Southern States, and both are perennials. These will probably be found well suited for feeding the Indian worms.

11. *Zizyphus vulgaris.*—The Zizyphus plant is a perennial shrub belonging to the Buckthorn family. It makes an excellent hedge fence, and is quite hardy everywhere in North Carolina. Zizyphus jujuba, the Jujube plant of Asia, is the species preferred by Indian silk-worms, but this is not hardy in the United States, except where the orange thrives.

12. *Lagerstroemia Indica.*—The Crape Myrtle. This is a shrub or small tree very common, and hardy everywhere in the Carolinas. It is a favorite food with many of the Indian worms, and will be found very valuable in the cultivation of these worms. It is best grown as a hedge plant.

For the sandhill and long-leaf pine regions the three last-named plants are likely to prove most profitable, as they all thrive upon dry, sandy soils, when properly fertilized. The castor-oil plant thrives only on very rich, moist soils, such as river bottoms.

The osage orange and the Moretti mulberry should always be grown in hedge form. The Downing, multicaulis and white mulberries may be grown as low-branching shrubs.

For a hedge plant the rooted cuttings or rooted seedlings in rows two feet apart in the row. Usually the hedge is used as a fence around a plot of ground, but it may be grown in rows 15 feet apart. For the tree or shrub form, plant 15 by 15 feet, and make the plants branch from the ground. Prune back severely every second year. The leaves should not be gathered before the plants are three years old, and after that gather only on alternate years, or at least give one year's rest in three. The ground should be kept cultivated from early spring until July, then sow the middle of row in cow-peas. Chickens or hogs may be allowed to run in a mulberry orchard, as both are very fond of the fruit. Poultry and silk-worms go well together, and make a good, all-the-year-round business.

All the mulberries except Downing are easily propagated by cuttings of mature wood, by root cuttings and sprouts, by grafting, budding and by seed. Seedlings of the common white mulberry are considered the best, especially for hedges. Nurserymen sell one-year seedlings for about $6.00 per 1,000. The seed should be soaked 48 hours before sowing, then sown about two inches apart in drills 12 inches apart. Cover about half inch deep and keep moist until the seed has germinated. The seed take 15 to 20 days to come up. The young seedlings must be well cultivated and the soil kept mellow. Pinch off all lateral twigs to force the growth into the main stem. If the ground is sufficiently rich, the seedlings should be fit to transplant the succeeding fall or spring. In transplanting use a dibble and set the plants a little deeper than they stood in seed-bed.

In propagating by sprouts, first cut back the parent tree very severely and loosen up the ground about it. Sprouts will come up all around. Fertilize the ground generously and let all grow for one year. Then carefully dig—not pull—up the sprouts and transplant to the permanent situation. This is a rapid and satisfactory way of securing a plantation.

To propagate by cuttings, take 12-inch cuttings of the two-year old wood. Plant thickly in rich soil just deep enough to cover all but the two uppermost buds. Cultivate cleanly and water in dry weather. Usually 50 per cent of the cuttings will root and may be transplanted when one year old.

Layers are made by bending down branches and covering all but a foot or so of the tip with soil.

If a nick is made every four inches of the part covered the branch will root at that point, and in this way a large number of rooted plants can be obtained from one branch.

Grafting or budding the mulberry is the least satisfactory way of propagating it. As a rule it will not pay anyone not a professional to attempt to graft the mulberry.

The pipe-stem or ring graft must be employed. Budding is even less satisfactory, as few of the buds live. Budding is done in the same manner as with the peach.

The mulberry is naturally long-lived, and is subject to few pests. Rotting of the trunk following wounds is the most frequent trouble. A good and cheap dressing for such wounds is the once celebrated "Forsyth's Dressing," made as follows:

Old cow manure, free from litter	16 parts.
Old mortar, finely pounded	8 parts.
Wood ashes	8 parts.
Clean sand	1 part.

Mix dry, and pass through a sieve. Wet with water enough to make a stiff batter. Smear this dressing upon the wound and allow to dry, then rub smooth with a burnt bone.

The best fertilizer for mulberry trees kept for silk-worm food is a mixture of one-half kainit, one-quarter acid phosphate, and one-quarter nitrate of soda. Where fowls are kept in the orchard little or no nitrate will be needed. The double sulphate of potash and magnesia may be substituted for kainit. A mixture of 200 pounds of muriate of potash, 600 pounds of acid phosphate, and one ton of stable manure makes a suitable fertilizer. But stable manure alone does not contain the necessary plant food to make the best quality of silk-worm food. It tends to produce a too succulent growth, which is liable to cause disease in the worms, especially Flacherie. Potash tends to make solid, starchy and nutritious leaves, and is, therefore, a necessary part of a good fertilizer for the mulberry. Acid phosphate tends towards rapid maturity of the leaves, which is also desirable.

IV.—Rearing the Mulberry Silk-Worm.

There is but one species of the cultivated silk-worm, but there are many varieties of this species named after the color of the cocoons, and a still greater number of cultural races. Every important silk-growing district has a special race, which is believed by the local inhabitants to be superior to all others. Among the best-known of these races may be specified the Umbrian, Ascola and Marches races of Italy, and the Cevennes, Var and Pyrenees races of France. The Italian races are more prolific, but less hardy than the French. Italian raw silk is admitted to be superior to the French, and vastly better than the Chinese.

In describing the life history of the silk-worm, we will begin with the egg, in which form a start is usually made in this business. The eggs can be bought in the market. They cost about $2.50 an ounce. The eggs of the silk-worm are yellowish, and about the size of a mustard seed. During incubation they change color, becoming violet or green. The common unit used in speaking of silk-worm eggs is the ounce. The standard ounce is equivalent to 25 grammes, and contains about 40,000 eggs. The mother moth lays between 300 and 400 eggs, so that it requires 100 females to produce one ounce of eggs. But as the insects mate but once, there must be an equal number of males in order to have fertile and viable eggs.

The progeny of one lot of eggs placed to incubate at same time is called an "education." For convenience and to save time, it is very necessary that all the eggs of one batch or "education" shall be of equal vigor and general constitution, in order that they may go through their metamorphosis and changes at the same time. To insure this, eggs from different sources should not be mixed together.

Though the eggs of the common mulberry silk-moth are produced in early summer—usually June—they will not hatch until they have passed through the regular seasonal variations of temperature, nor with ordinary treatment can they be made to hatch until after six months. After March 1st, however, a warm spell of weather is liable to start the dormant life process long before the mulberry or other food is available. To prevent too early hatching, it is the custom in Italy to send the worms from the lowlands, where most of the silk is grown, into the cold valleys of the Alps during the month of January. Here the worms are subjected to a temperature usually many degrees below the freezing point—often 10 degrees F. The same result is effected by putting the eggs into a dry refrigerator for about a week. The period of severe cold is thought to harden the worms and make them less liable to disease. So long as they are kept dry, no ordinary amount of cold will injure the eggs. But the more severe the cold, the slower the eggs are to hatch when put to incubate. On no account should the eggs be kept at or near a uniform temperature during the entire dormant period. The silk-worm is not a tropical insect. It is habituated to climatical variations of temperature, and when these fail the eggs spoil. The eggs must not at any time be exposed to strong or direct sunlight. The period of incubation is about six days, at a temperature of about 73 degrees F. When the eggs are set to incubate, the temperature must be gradually raised, beginning with the natural temperature, which is, in the first week of April, about 48 degrees F. Increase slowly to 55 degrees F. during first 6 days. Hold it so for 4 days, then increase one degree per day until it reaches 67 degrees F. Hold it so for 2 days. Then increase one degree per day until it reaches 72.5 degrees F. to 73 degrees F., and hold it so until eggs hatch.

The eggs will usually hatch in six days after the temperature of 72.5 degrees F. is reached. The whole period from first raising the temperature above the temperature of the season to the hatching should be about 20 days. Therefore, in North Carolina the start should be made about April 10th, so as to bring the worms by May 1st. It is very desirable to have the worms out as early as food can be had for them in order to escape the heat of June during the spinning-up process. The silk-worm is unable to stand much heat.

An ordinary chicken incubator may be used for hatching the eggs, or a small room which can be well ventilated may serve; a small tile stove may be used to heat the room. The floor of room must be frequently sprinkled in order to keep the air moist. In the incubator, use a wet sponge, as in hatching fowls' eggs. A good incubator in which the temperature is regulated automatically is the safest and best way to hatch silk-worm eggs.

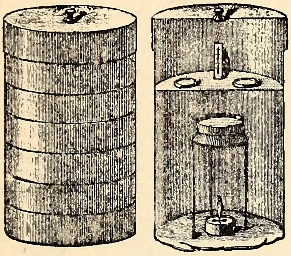

Fig. 6.—Silk-worm Incubator.

Fig. 6 shows a form of silk-worm incubator commonly used. Any tinsmith can make one of these. The lower part containing the lamp must be well ventilated so as to remove all gases. The eggs usually come to hand glued by the mother insect to squares of cloth—each square having about 300 eggs (see Fig 10), but some breeders scrape them off the cloths. To incubate, the cloths or saucers are simply laid upon shelves, or better, on a lattice frame which allows the air to circulate freely on all sides. While the eggs are incubating, the rearing-room must be carefully and thoroughly cleaned and disinfected. First, scrub all the woodwork with soap and hot water. After it has dried, fumigate with burning sulphur, using three pounds of roll brimstone to each 1,000 cubic feet. A room 10 by 10 feet contains 1,000 cubic feet. To fumigate, break the sulphur into small pieces. Place in a heavy iron pan. Float this pan in a tub of water in the room. Throw upon the sulphur a shovel of hot coals and quickly vacate the room. The room should have been made air-tight. Let stay closed 12 hours. After fumigating, the walls should be whitewashed. The most scrupulous cleanliness must be maintained during the entire "education" of the worms.

The question of space is one of very great importance in raising silk-worms. The worms are very small at first, but they increase rapidly, and the space they occupy must be extended in proportion. Silk-worms must never be stinted in room. At birth, a silk-worm weighs about .01 grain. After first molt, when 5 or 6 days old, it weighs .15 grains. After second molt—8 to 10 days old—it weighs .94 grains. After third molt—15 or 16 days old—it weighs 4 grains. After fourth molt—21 or 22 days old—it weighs 16 grains. When ready to spin up—30 to 33 days old—it weighs 95 grains.

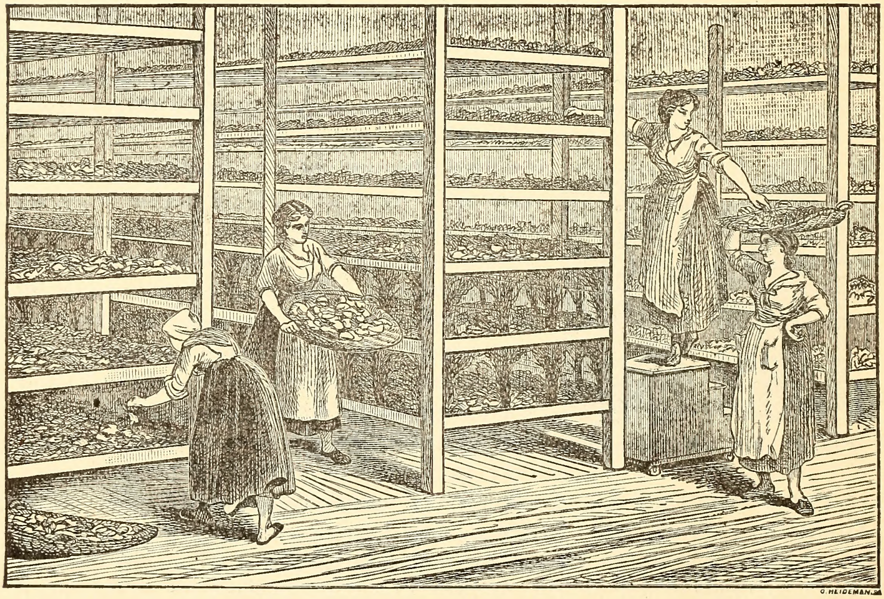

Fig. 7.—**Breeding Room for Silk Worms.**

There are many ways of arranging the worms for feeding. In average "educations," a good way is to have light wooden trays, with bottoms of cheese cloth, mosquito netting, or soft manila paper perforated with holes just large enough for the worms to climb through. The holes may be increased in size as the worms grow. These frames or trays have blocks or feet at corners to raise them a little from the surface and allow a free circulation of air. Worms are voracious consumers of oxygen as well as leaves. A good size for these trays is 1 by 3 feet. When the eggs begin to hatch, lay the plate on a table and place over it and just above it one of the trays, right side up. In the tray place some fresh-chopped osage orange, mulberry or scorzonera leaves. The young worms will, as soon as hatched, climb through the holes in the bottom of the tray upon the leaves. As soon as the tray is one-third occupied, remove it and place a fresh tray. The eggs usually begin to hatch early in the morning. The period of active escape from the shells may continue for several days, but the worms of each 12 hours' hatch should be kept separate. The eggs not hatched at the end of the third day from the first hatching should be thrown away, as too weak to produce vigorous worms.

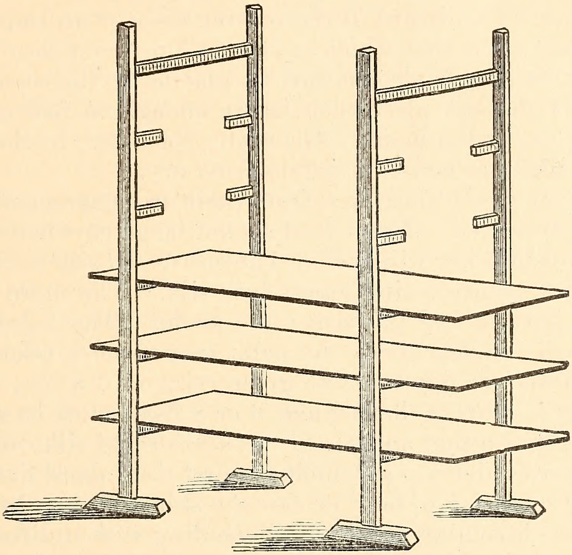

Fig. 8.—**Shelves for Feeding Silk Worms.**

One or more rows of shelves or movable standards should be arranged in the center of the breeding-room—never along the sides. It is impossible to give the room too much fresh air. But too much light is injurious. The temperature must be carefully regulated. Until the first molt, keep the temperature of breeding-room about 73 degrees F.; after first molt, increase to 75 degrees F.; after second molt, increase to 76 degrees F.; after third molt, 78 degrees F.; during last ten days, make temperature 80 degrees F.

Iron stoves must never be used in a room where silk-worms are bred. Open fire-places are good, but the best method of heating the room is by hot-water pipes or tile flues, such as are used in heating greenhouses. In Italy there is made a kind of tile stove or box which gives very good results.

Too much care can not be taken to keep the temperature uniform and make the worms as comfortable as possible during their whole lives. An excess of heat is more injurious than a deficiency, but both are bad. Sudden changes of temperature are very injurious. Fresh air in plenty must be given, but drafts must be guarded against. A reliable thermometer is an absolute necessity in the rearing-room. Several of these should be hung in different parts of the room, and one outside, but protected from the sun. Do not use cheap, ten-cent thermometers. Get a good one, which can be had for about 40 cents. A good general rule to follow is to keep the rearing-room at all times as warm and free from odor as is customary in the family living-room.

The amount of moisture in the rearing-room is an important matter. The best air is that which is about 65 per cent saturated. In a rough way this may be determined by placing in the room a plate of dry salt. If the salt absorbs moisture enough to feel moist to the touch, the room is too moist. Generally speaking, in the South the air is more likely to be too moist than too dry.

Keep worms at all times free from their own excrement, and from stale, dried-up leaves. Fresh food should be given whenever the last feeding is consumed or withered. The cultivated silk-worm is simply a machine for transforming leaves into silk. The more it eats, the greater the harvest and the larger the profit. The silk-worm as an eater is worthy to bear away the palm even from a school-boy. At least four feeds per day must be given, viz., at 6 a. m., 10 a. m., 2 p. m., 6 p. m. During the last age, 6 or 8 feeds must be given. Experience has shown that an average "education" of silk-worms will, at the temperatures above noted, molt for first time about five days after birth. The intention to molt or cast the skin is shown by the worms ceasing to eat, becoming restless and standing with uplifted head and tail. No food should be given after any worms in a tray show these signs of molting. The periods between successive molts are called ages. Silk-worms pass through 5 ages, lasting about as follows: First age, 5 or 6 days; second age, 4 or 5 days; third age, 5 days; fourth age, 5 or 6 days; fifth age, 8 or 10 days. The progeny of one ounce eggs—about 40,000 worms—will, on the average, consume the following weight of fresh mulberry leaves during the 5 ages above described: First age, 9 to 11 pounds; second age, 25 to 30 pounds; third age, 80 to 110 pounds; fourth age, 275 to 350 pounds; fifth age, 1,600 to 1,900 pounds. Total for progeny of one ounce of eggs, 1,980 to 2,390 pounds of mulberry leaves.

Experience has shown that the above-given quantities of leaves can be gathered from 12 trees annually, or every second year from 24 trees, of white mulberry or its varieties grown in tree form. The trees must be over five years old and in good health, and kept growing vigorously by cultivation and manure.

After each molt, the brood of worms must be "rarified" or spread out. As soon as the worms have recovered from their molt, transfer to fresh trays, and give the worms in each of the former trays just three times as much room or space as they had before. This is very important, as crowded worms soon become sickly and are liable to breed an epidemic.

In changing the worms into fresh trays, they must never be touched with fingers. By means of perforated-bottom trays and fresh food the worms are easily transferred. Some worms will refuse to pass up into the fresh tray. These, if they are unusually small or inactive, should be thrown away as weaklings. If worms must be transferred by touch, use a fine camel's hair brush. Never squeeze the worms.

The trays with worms feeding are best kept on shelves, made of laths set on edge and nailed to cross pieces. This insures free circulation of air from below. The shelves, if placed one above the other, should be about 24 inches apart. The amount of space required by the progeny of one ounce of eggs is 10 square feet during first age; 30 square feet during second age; 90 square feet during third age; 270 square feet during fourth age; from fourth to spinning-up, 810 square feet. If the worms are kept in trays of uniform size of 1 by 3 feet, the number of trays required at any time is found by dividing the number of square feet above given by 3.

To recapitulate: The requisites for a successful "education" of silk-worms are, 1stly, eggs free from hereditary taint; 2dly, worms of uniform age and constitution; 3dly, plenty of mulberry leaves for food; 4thly, plenty of room to grow and expand; 5thly, plenty of fresh air and an agreeable temperature; 6thly, perfect cleanliness.

Spinning the Cocoon.—About the eighth day of the last "age," the worms begin to show signs of restlessness, such as announced the previous molts. They shrink in size, cease to eat, and wander about throwing out silk threads.

The five accepted signs of completion of growth in the silk-worm are as follows:

1. The worms cease to eat, wander about aimlessly, and stand with uplifted heads.
2. When viewed horizontally in the direction of a lighted window the worms appear of a plum-yellow or almost transparent color.
3. The worms crawl upon the edges of the trays and show a determination, not previously seen, to climb.
4. The rings or segments of the body contract and change into a lighter color.
5. The skin becomes wrinkled and the entire body becomes soft and satiny.

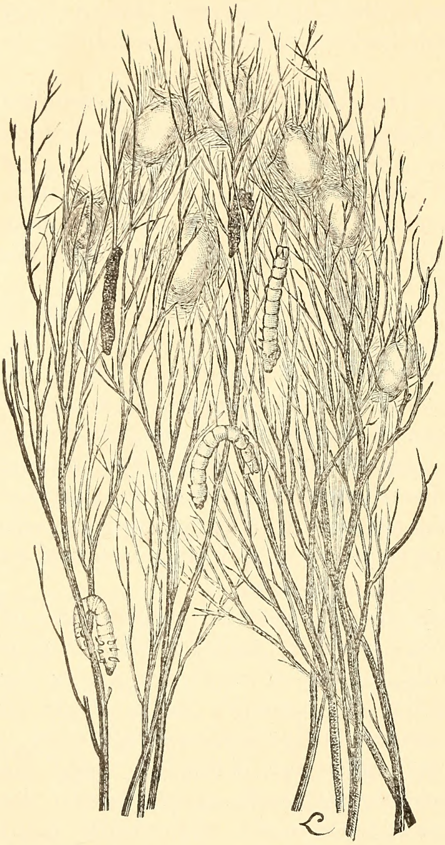

Fig. 9.—**Brush for Spinning the Cocoons.**

The brush for the worms to spin upon must then be prepared. These are dry twigs of oak, chestnut or other trees free from odor and gum. The twigs should be copiously branched and about 18 inches long. Place them in bunches along the shelves on both sides, at intervals of 12 inches. Tie the interlacing branches so that the arches will not fall apart. If the worms have been reared in trays, place the trays under the arches. The worms will soon mount into the brush and begin to spin their cocoons. There are a few worms in every brood which refuse to mount into the brush. To accommodate these, remove the trays from beneath the arches and place over each tray a few of the brushy branches. These worms will spin their cocoons in the branches thus supplied. If any refuse to climb and appear sluggish or sickly, after the 12th day of the last age, throw them away.

During the last few days of their larval life the worms give off an enormous amount of matter in the form of gas. Special care must therefore be taken to keep the room well ventilated, yet drafts must be avoided.

The period of mounting the brush and spinning the cocoon is the most critical in the entire life of the insect. Neglect or wrong treatment at this period is apt to prove fatal to the creature and to the owner's profit. Until the danger is passed and the cocoon is spun someone should be constantly with the worms to ensure that everything is as it should be.

Usually four-fifths of the worms will have mounted within 24 hours after the first one did. But there need be no hurry in pushing the mounting. Give them all the time they want. Those which remain and continue to feed after the 24 hours are over should be removed to a separate room which is heated 5 degrees above the main room, and there fed as much as they want. The extra heat will probably bring them to the mount within 24 hours. Return them when they show intention to mount.

Remove the trays and clean the woodwork as soon as all the worms are mounted. Increase the ventilation to the utmost. Drafts need no longer be feared after the worms have spun their floss covering. Heat is what is now to be avoided. Sprinkle the floor frequently to cool the room. Remove at once any worms which become sick or die in the brush. If two worms begin to spin close together, with a camel's hair brush or a twig remove one to a distance. While the worms are spinning their cocoons the utmost silence and quiet must be maintained. Whenever the worms are disturbed at this time they cease work. This makes a kink in the filament where it will probably break in reeling.

The temperature of the room must be kept as near as possible to 80 degrees F. during the process of spinning, which usually lasts three days. It is very important that the temperature be 80 degrees F., neither less nor more. If lower, the silk does not flow freely in the worm's spinnerets. If higher, the worm is liable to premature exhaustion and may fail to complete the cocoon.

The worms which show no signs of wanting to spin, after general spinning has begun, should be fed sparingly until they do. But the trays are likely to soon become foul from the excrement of the worms which have already mounted. Cloths must be used to keep the trays clean at this stage. The worms in the brush must also be watched closely. If two or more are so close together that they are likely to spin compound cocoons, the worms must be gently separated by aid of a soft camel's hair brush. Double cocoons are worthless for reeling. Such cocoons must be sold for waste silk, which is worth only one-quarter as much as reeled silk.

When the cocoon is completed—which requires about two days—the worm within casts its skin for the fifth and last time and takes on the form of *pupa* or *chrysalis*. In this condition it is surrounded by a hard, horny shell. The interior of the worm melts up and reforms into the shape of the winged moth. The process of transformation requires 12 to 15 days. At the end of this period, if the chrysalides have not been killed or "choked," the winged moth pushes her way through one end of the cocoon. Such pierced cocoons are useless for reeling, but may be used for carding as floss silk. They are worth about one-fifth the price of prime choked cocoons.

The cocoons for reeling should be gathered from the brush about 10 days after the first spinning began. The brush is carefully taken apart and the cocoons, which are only lightly attached, are separated from the branches with the fingers. They are at the same time separated into grades according to color, size and firmness. The cocoons, especially those which lack firmness, must be carefully handled, or the chrysalis within will be injured, will putrefy and stain the silk, which then has only the value of waste silk. After classifying the cocoons, the largest and firmest should be picked out for "seed" for next year. For each ounce of eggs, or "seed," that is wanted, 200 cocoons must be saved. The remainder of the cocoons are to be at once "choked" to kill the chrysalides. "Choking" is usually accomplished by putting the cocoons into a covered, perforated-bottom tin vessel like a kitchen colander and setting this for one-half hour over a kettle of vigorously-boiling water. A few chips of wood should be put into the kettle to prevent the bubbling water from spattering and staining the cocoons. Instead of steaming, the cocoons may be choked by putting them into an oven and heating to 140 degrees F. for 4 to 6 hours, or as long as a humming noise can be heard when the cocoon is placed to the ear. After "choking" by steam the cocoons should be thinly spread on a sheet in the shade and allowed to dry out thoroughly. This is not necessary when dry heat is used. After the cocoons are dry, they will keep indefinitely, provided they are preserved from weevils and mice. It is usually best, however, to sell at once. It is not desirable for any American silk grower to attempt to reel the silk at home: It is impossible, by the utmost skill even, to make as good a quality of silk by hand-reel as can be made by the improved automatic power reel. In communities where as much as 10,000 pounds of fresh cocoons are raised annually, it will pay to put up a co-operative reeling establishment. A reel may be run by steam, water or electric power—using about one-half horse power per basin. To produce 1 pound of raw silk requires 12 pounds of fresh or 4 pounds of choked and dried cocoons.

The Production of Eggs.—The production of eggs for sale is, in all old silk regions a special branch of the industry, carried on by those who make a specialty of it—just as seedsmen grow seed for use of gardeners. But in all new countries each gardener and silk grower must, at first, produce his own seed.

We have already shown that for each ounce of "seed" 200 of the finest cocoons must be laid aside. These cocoons, at market price, are worth about 30 cents. The ounce of seed they will produce is worth, at market price, about $2.50. The selected cocoons are first with a needle and thread carefully strung into chains of 3 or 4 feet long. The thread should only pass through the loose, floss silk at middle of cocoon. Hang the cocoons from ceiling in a cool, dark attic or dry cellar. If very numerous they may be laid upon a clean, cloth-covered table in a layer not over two inches deep. They should be stirred once a day so as to give all an equal chance to secure air. If kept on a table the legs of the table must be stood in buckets of water to keep off ants and mice.

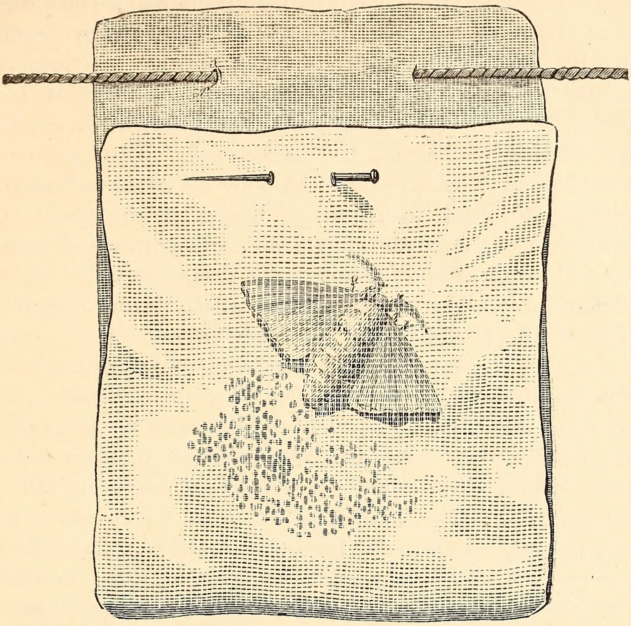

Fig. 10.—Silk-moth and her Eggs in a Cloth Pocket.

During the chrysalis or pupal stage, and the subsequent period of egg-laying, every expedient must be practiced to keep down the temperature, which, on no account, should rise above 73 degrees F. The best temperature during the pupal and egg-laying stages is 68 to 70 degrees F. Usually in the Southern States during June this temperature can be secured only in a dry cellar, and this will probably be found to be the best place for egg-laying. Where the temperature rises above 73 degrees the eggs are apt to be poorly fecundated. The same happens if the temperature falls below 68 degrees during egg-laying.

The moths will emerge within 12 to 18 days from date of spinning first cocoon. They usually appear in early morning, and cluster upon the cocoons. Though they have wings, the moths never attempt to fly. They have no mouths, and therefore eat nothing. The sole end and aim of their existence is to produce and lay eggs. Then they die. Before the moths emerge, squares of clean cheese cloth about 3 by 3 inches are prepared—one-half as many squares as there are cocoons. Instead of squares, bags or pockets of cheese cloth 3 by 3 inches, with a flap of one inch at upper end, may be used, and are much better than the simple squares. The cloths should have been previously boiled in clean water for one-half hour and then dried, to kill chance spores of disease and remove from cloth gum or other substances which might injure the eggs. The moths will issue from 5 a. m. to 8 a. m. The two sexes are usually about equal, but it often happens that the male moths issue first. The sexes are easily distinguished by the slender body and longer antennæ or "feelers" of the male, and his greater agility. The female is much larger and heavier, being gorged with eggs. The sexes couple in an hour after issuing and while still clinging to the cocoons. They are to be left so for about six hours. The room should be kept very dark and quiet, but with plenty of fresh, moist air. Temperature about 70 degrees F. After six hours, place the prepared cloth squares or bags, turned inside out, and separated by about two inches, upon a flat table or shelf. Take up a couple of moths and separate them by gently pulling on the wings of the male, throw the male into a basket prepared for that purpose. Allow the female to rest for a few minutes on a clean board, until she has ejected a quantity of reddish fluid. Then pick her up and place her upon one of the cloth squares or pockets. She will at once begin to lay her eggs, and will keep it up for about 36 hours, during which time she will have laid between 300 and 400 eggs. She dies soon after finishing, but must not be thrown away.

Fold over her one corner of the cloth on which she laid her eggs, and pin her there. The body must be so kept until it has been examined with a microscope to determine whether or not she was free from the germs of the Pebrine and Flacherie diseases. The moth is crushed in a mortar with a little distilled water, and a drop examined under a lens magnifying 400 diameters. If any moth shows evidence of this disease, the body and all the eggs she produced must be burned, as this disease is hereditary and contagious. Eggs produced by a diseased moth are worthless, as the worms would not live through their complete life cycle, and would convey the disease to other worms of same "education."

It rarely happens that the cocoons set apart for egg production give out more females than males. When this occurs, after the sexes of those coupled have been together for two hours, they may be separated by gently pulling on wings, and the males may be used over again for virgin females. In such a case the moths must not be separated for 24 hours. This is seldom necessary. After the eggs are deposited upon the cloths, they soon harden and become glued to the cloth. No further treatment is required, other than the microscopic examination of the mother insect. This work requires greater skill and more expensive appliances than the average silk-grower possesses. It is usually best to send the cloths with eggs and mother attached to some scientific laboratory for examination. It is sufficient to send the moth alone, and if a number is placed upon the cloth and the same number attached to the moth, the eggs of any particular moth can be identified. But confusion is liable to arise by misplacing numbers. It is safer and better to keep the moth and her eggs together until the microscopic examination has been made. After the eggs are certified free from disease, they should be packed lightly, still on the cloths, in a ventilated tin case and hung from the ceiling of a cool, dry room. Rats, mice, ants and weevils are all very fond of silk-worm eggs.

We have already seen that the eggs can not be made to hatch until after 6 or 8 months. No particular care is needed as regards temperature, but the eggs must be kept dry and not be exposed to direct sunlight. Certified eggs of the best races are worth in the market $2.50 to $3.00 per ounce. For Southern silk growers the large yellow races of Italy are specially recommended.

The white Japanese races produce finer silk, but in smaller quantity, and are not as valuable when growing for the general market.

When once a good local variety of silk-worm has been evolved that should be carefully bred and improved, and made the standard of the locality. Growers can not be too strongly cautioned against introducing strains of worms of unknown origin or value. Acclimated breeds are best. Well-bred and constantly-selected strains do not degenerate. The American-bred silk-worm is equal to the best, and when a local race has been created it is folly to supersede or mix it with foreign blood.

Silk growers should form local associations and endeavor to build up a local sentiment towards creating and preserving the local, standard brand, and for establishing co-operative filatures and sales-markets.

Silk Gut.—Silk gut is an article of interest and use for rod and line fishermen. Gut is made from the same substance as raw silk, but in procuring gut, the worm, just before it is ready to spin up, is killed by throwing it into strong vinegar or weak acetic acid for an hour or two. The silk spinnerets are then opened and the silk is forcibly drawn out into two threads very much thicker than that the worm naturally spins. These threads are steeped and hardened in cold water, and afterwards washed in a solution of castile soap. The threads are next manipulated and rubbed between the fingers until a thin epidermis peels off. The gut is finally dried in the shade. In some places the gut is bleached by sulphur fumes after drying. Each worm gives about 18 inches of thread from each spinneret. The threads are usually assorted and put up in bundles of 100. They are sold wholesale in dozen bundles at about $2.25 per dozen. It requires about 18,000 of these threads to weigh one pound. The demand is pretty good. At present the supply comes almost wholly from Spain. The gut from the Indian silk-worms is much stronger and better than that from the common worm.

The methods of caring for the silk-worm detailed in this chapter apply strictly only to the mulberry worm. The three Indian worms described in this BULLETIN will require somewhat different treatment, which is detailed in the special descriptions of these worms. In a general way, we may state that the Indian worms may be reared indoors on trays, but being larger will require more room and more food than the mulberry worm. The temperature, too, must be kept about 15 degrees F. higher than is good for the mulberry worm. The food leaves and air of room must be kept very moist. The Indian moths do not lay their eggs on cloth, but in boxes of straw or loose and dry leaves. The cocoons are spun on brush after the manner of the mulberry worm. The Indian cocoons must be macerated in 3 per cent soda or potash solution instead of pure water.

V.—REELING THE SILK.

Reeling silk, or, in other words, unwinding the silk from the cocoons, combining several of the worm's threads into one compound thread and reeling this into skeins, is a process of manufacture which about doubles the value of the natural silk. Skill in reeling has become hereditary among the silk-growing peasantry of Italy, but modern automatic, power reels can produce a much better grade of silk from same cocoons than the most skilful Italian hand-reeler. The hand-reel is now obsolete and can not be profitably employed in competition with power reels. It should have no place in the American industry.

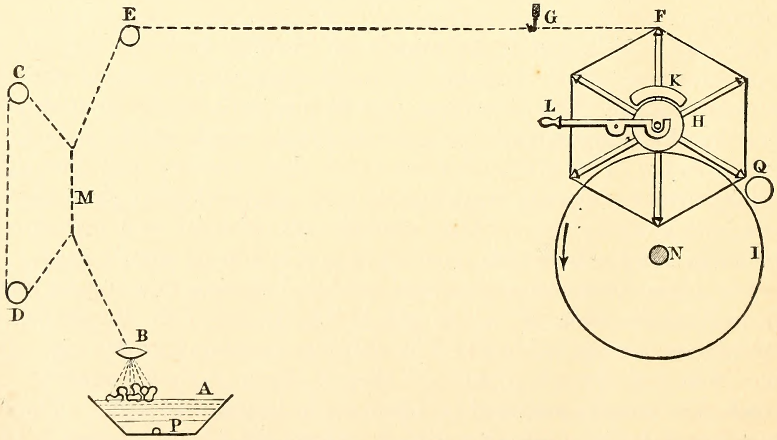

Fig. 11.—**Automatic Power Reel.**

A, basin of water; B, "eye" of basin for uniting several threads; C and D, pulleys for pressing water out of thread; E, support; G, travelling pulley for spreading the silk over the reel, F; N. I, driving wheel; L, break; P, waste ends from cocoons.

Silk reelers classify cocoons into eight grades, viz:

1. Prime cocoons. Hard, fine-grained, unspotted cocoons.
2. Calcined cocoons. These have dead, petrified worms within. They may, however, be of first-rate quality.
3. Pointed cocoons. These are thinner at the pointed end than at other ,and do not reel well.
4. Large, but soft cocoons. These have coarse, brittle fiber and are difficult to reel.
5. Soft cocoons. These are loosely spun, resembling floss silk. They can not be reeled, but must be combed.
6. Double cocoons. These are cocoons formed by two worms in common, and have their filaments intertwined at one end. They can not be reeled.
7. Perforated cocoons. These have one end perforated by the escaping moth. They can not be reeled.
8. Stained cocoons. These are cocoons stained by the death and putrefaction of the worm within, or by filth from without. They may vary in value from second grade to worthless.

In forming the cocoon the worm works from within. It first throws out a loose, irregular covering, which forms the "floss" of the cocoon. After this it proceeds in a more regular manner, laying down the silk in close "figure-of-eight" loops. These are cemented by a sort of gum, which makes a continuous and very tough fabric from the different and separate strands of silk. To unwind this silk, the loose or floss silk is first torn off with the fingers. This silk is combed and spun in same way as wool. The tough inner part, called the "pod," is next thrown into a basin of water kept at a temperature of about 150 degrees F. Here it is beaten and stirred with a small whisk-broom until the gum softens and the silk thread shows signs of falling apart. One of these threads is caught on the brush of the broom and unwound until the outer end is found. Four or five similar threads are caught and passed through a glass or brass "eye" on the edge of the basin. The compound thread thus formed is twisted upon itself or upon another thread to get rid of surplus moisture. Some reels pass the thread through a heated box to further dry it before it is wound upon the drum. The length of the natural thread spun by the worm is about 4,000 feet. Its diameter is greatest in the center and tapers to both ends. In reeling the compound thread it is of prime importance to have the thread of uniform diameter throughout. To accomplish this, a fresh thread from the basin must be added from time to time to make up for the growing thinness of the other threads. This requires great judgment on the part of the reeler, but is accomplished automatically and with far greater precision by the improved reels.

The best reel is the Serrell, an American invention. Good reels are also made by Pozzi Bros., at Milan, Italy; by Giovani Battaglia, Luino, and Pierino & Cecco, Udine, Italy; and Berthaud & Son, Lyons, France.

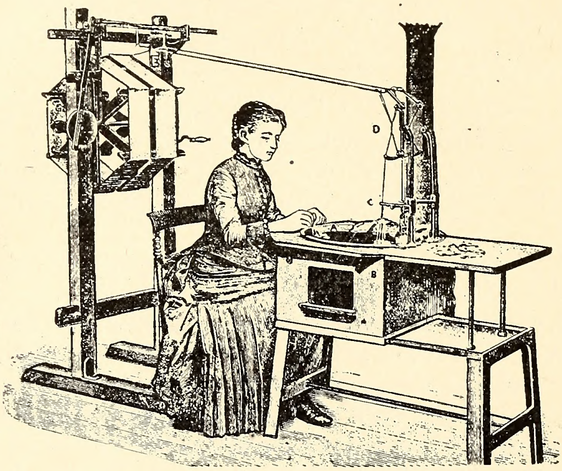

Fig. 12.—**Italian Silk-reel.** A, basin; B, charcoal heater; C D, guides; E, drum.

The American reel costs about $80.00, the Italian and French reels about $50.00. Prices in either case do not include power or fittings. With either of these reels, run by steam or water power, a woman with a girl to help can reel from one and a half to two pounds of raw silk per day. The following figures as to cost of reeling are given by a Consul of the United States in Italy:

Wages of a woman reeling, per day	$0.55
Wages of girl brushing, per day	.15
Cost of fuel	.35
Rent of machine and room	.15
Interest on cost of cocoons	.20
Loss on cocoons	.08
Taxes, insurance, etc	.10
Total cost of reeling 2.2 lbs. silk	1.58
Less value of waste silk	.08
Net cost	1.50
Cost per pound of raw silk	.72½

Reeling mills or "filatures" are in Europe usually connected with weaving factories, or are owned by commission houses, who gather up the cocoons from a large district. But any neighborhood which produces at least 10,000 pounds of fresh cocoons annually may profitably establish a local filature. A single "basin" or reel costs from $40.00 to $80.00, not including power or fittings. This will reel from one to two pounds of skein silk per day of ten hours. In 300 days a single "basin" will work up 3,000 to 4,000 pounds of fresh cocoons. A single basin, however, can be profitably run only in connection with some other industry requiring power from which the reel may borrow. The smallest custom filature that can be profitably established has three basins, and will work up about 10,000 pounds of cocoons in a year. With the improved automatic reels silk reeling calls for no more mechanical skill than cotton ginning. There is no reason why silk reels may not be established in connection with cotton gins.

The following suggestions for reeling silk are offered by an experienced Italian reeler:

The room must be dry and free from drafts. The water used must be of the softest and free from sediment. Different qualities of cocoons require different temperatures in the water, varying from 140 degrees F. to 200 degrees. The water must never boil. Only carefully assorted cocoons of the same grade should be put into the basin together. Maceration requires from two to seven minutes. The brushing is accomplished with small whisk-brooms. The cocoons are beaten and stirred until an end is caught, which is stuck on the rim of the basin until several, usually five, are found; these are then taken together and passed through the "eye" and over the pulleys upon the drum. The reel must be turned as fast as the cocoons will unwind. If the cocoons tend to rise from the water, the water is too hot. When a skein is finished, the end must be tied with a white rag or a cord with a card attached so that the end can be readily found. The skein must not be removed from drum until it is thoroughly dried, which requires about 10 or 12 hours.

VI.—Diseases of Silk-Worms.

The silk-worm is subject to several grave diseases, which are described below. As the worms are reared under cover and with constant attention, they are not subject to the attacks of other animals, except mice and weevils.

1.—Pebrine.

Pebrine is a bacterial disease, which in years past has wrought enormous damage in the silk-growing regions of France and Italy. Thanks to the researches of Louis Pasteur, this disease is now easily prevented. Pebrine is hereditary, being transmitted to the eggs by the mother moth. To prevent the appearance of pebrine in a rearing-room, only eggs certified by a competent microscopist to be free from germs of pebrine should be incubated. A microscope for examining moths for pebrine must magnify at least 400 diameters. A good instrument will cost about $30.00. We recommend those made by Bausch & Lamb, of Rochester, N. Y. If infected eggs are incubated, the worms will die before completing their last molt, and will in the meantime infect the healthy worms in same room. Pebrine is as contagious and destructive to silk-worms as cholera is to human beings. When silk-worms die during the rearing process from whatsoever cause, the dead worms should be removed and burnt, and the healthy worms removed to a fresh tray or clean shelf. No dosing or topical treatment for pebrine is of any value. The use of eggs infected by the germs of pebrine is the main cause of some recent failures of silk growing in the United States.

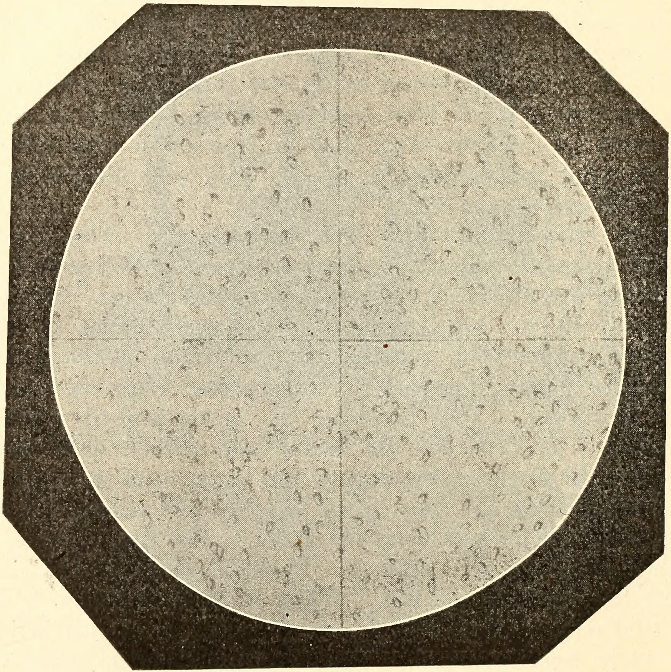

Fig. 13.—**Pebrine.**

2.—Muscardine.

Muscardine is a disease due to a parasitic fungus which attacks the worms. The same fungus attacks other insects, especially the house-fly. House-flies may transmit the disease to silk-worms. Silkworms are more commonly attacked by muscardine during their last "age." The attacked worm dies suddenly and soon discolors and becomes stiff and hard. In about 24 hours thereafter the worm becomes covered with a whitish powder, which is the spores or "seed" of the fungus. These spores may be borne about by the air and so be carried to still healthy worms. The spores also are carried to the walls of the room and upon the shelves, etc., used in rearing the worms. In such places the spores of the fungus retain their vitality for over a year. Unless the room and all woodwork is thoroughly cleaned and fumigated, these spores are certain to infect the new brood.

The only treatment for this disease is cleanliness and thorough disinfection of the breeding-room before the worms are hatched. House-flies should be kept out of the breeding-room at all times. Dead worms, or even those sick, should be removed and destroyed as soon as observed. Beginners in silk growing must, however, be careful not to confuse the natural sickness of the worm preceding molting with muscardine or other contagious diseases.

3.—GRASSERIE.

Grasserie, also called *Jaundice,* is generally present when the broods are large and where succulent food is used. Worms fed upon osage orange leaves are much more liable to this disease than those fed on mulberry. This disease is dangerous where the worms are kept in large numbers. The exact cause of the disease is not well understood, but it is believed to be due to bacteria acting upon the worm when its digestive apparatus is enfeebled by too succulent food. The only practicable treatment is to avoid wet and succulent food—feeding only leaves which have been picked and kept under cover for 12 or 14 hours. The leaves should not be gathered when wet, or if they must be, they should be dried under cover before being fed. To prevent fermentation the leaves while drying must be frequently stirred with a wooden—never iron—fork.

Mulberry leaves grown on wet soil are very liable to cause jaundice, as are those from rank-growing sprouts. On the other hand, old and tough leaves fed to very young worms are equally liable to cause digestive trouble. The following three points are of capital importance in feeding:

1. Feed only dry, clean, healthy leaves.
2. Feed young leaves to young worms—old leaves to old worms.
3. If a change of feed must be made from one species of plant to another, feed the new kind very sparingly at first, so as to gradually effect the change.

The presence of Grasserie always indicates inefficient care on part of silk grower, or bad management in the rearing-room. Observe the same precautions in regard to cleanliness and destruction of diseased and dead worms as above recommended for pebrine.

4.—FLACHERIE.

Flacherie, also called *Pallor,* is now the most dangerous disease of the silk-worm, and one for which we know no remedy.

The symptoms of pallor are drowsiness and diarrhœa. The body first grows soft and flabby, shrinks and turns black. Sometimes the worms burst and give out a very offensive odor. Pallor is always worst when the worms are crowded, and when the trays and shelves are not kept scrupulously clean, or when wet or diseased leaves are fed. A high temperature is also very conducive to this disease. The only practicable treatment is that advised for the other diseases—scrupulous cleanliness, plenty of fresh air, good, but not too succulent food, and the early hatching of the worms so as to insure their spinning-up before hot weather comes on. This disease is hereditary and contagious.

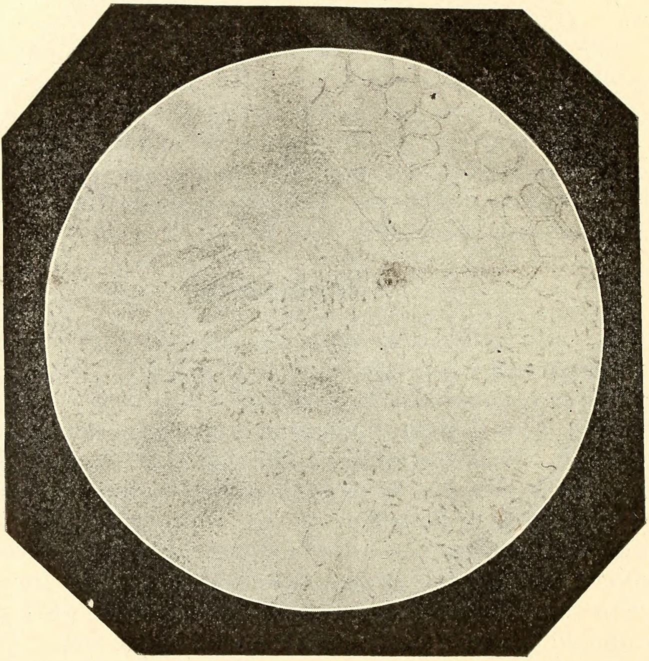

Fig. 14.—**Flacherie**.

5.—TRIPES.

Tripes is another name for suffocation. The silk-worm breathes through spiracles or holes in its sides. When by the accumulation of dirt, or when the worms are so crowded that they are compelled to overlie each other, these breathing holes become clogged and the worm literally suffocates.

The remedy for Tripes is the obvious one of perfect cleanliness, abundant ventilation, and plenty of room for the worms in the trays.

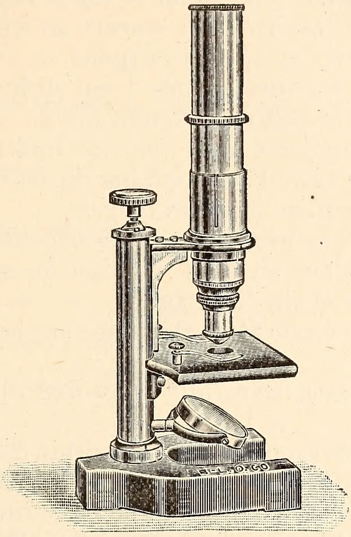

Fig. 15.—**Microscope for Examining Moths for Pebrine and Flacherie.**

6.—Chilling and Overheating.

Sudden and great changes in temperature are very bad for silkworms. A single chill or a "hot wave" may ruin in a day an entire batch of worms! A uniform, comfortable temperature night and day in the rearing-room is an absolute necessity in producing high-grade silk.

VII.—General Rules for Silk Growing.

1. Incubate only eggs certified to be free from pebrine.
2. Clean and fumigate the incubating and rearing-rooms before the eggs or worms are placed therein.
3. Practice the most scrupulous cleanliness and attention to feeding and ventilation during the entire rearing period.
4. Discard all eggs which remain unhatched after three days from time the first eggs of same brood hatched.
5. Cut or hash the leaves for the first five days after the worms have hatched.
6. Never feed dirty, wet, cold or diseased leaves. Pick the leaves 12 hours before they are to be fed, and cover them with a clean sheet. Do not keep the leaves in same room with the worms. After the first age unchopped leaves may be fed.

7. Feed the worm in perforated, cloth or paper-bottomed trays laid on lathed shelves.

8. Change the trays or papers for clean ones as often as they become soiled. Throw away all sick worms every time the litter is changed. This does not refer to the sickness which precedes molting.

9. Separate and "rarify" the worms as often as they become crowded. Give plenty of space to expand in.

10. Never place together worms from different lots of eggs, or worms which have hatched on different days.

11. Never disturb worms while they are molting.

12. Prepare before hand for spinning the cocoons an ample supply of dry, clean, odorless and gumless twigs.

13. Form the arches with these twigs over the shelves or trays as soon as the worms show signs of wanting to spin, which is usually about the eighth day of the last "age."

14. Remove the cocoons from the twigs on the tenth day from first spinning-up.

15. Assort the cocoons carefully according to size, color and firmness.

16. "Choke" the cocoons for reeling within 24 hours after removal from the twigs. Choking may be done by live steam or hot air.

17. If cocoons are selected for "seed," take the finest ones. String them on threads and hang in a dark room. For one ounce of seed, take 200 cocoons.

18. Cause the moth to deposit on squares or pockets of cheese cloth 3 by 3 inches. Let eggs remain on these cloths until hatched.

19. Keep the moth and eggs together until the moth has been examined by a microscopist for germs of pebrine.

20. Never buy or sell any but certified disease-free silk-worm eggs.

VIII.—THE FUTURE OF THE SILK INDUSTRY IN THE UNITED STATES.

The United States is now the greatest silk manufacturing country in the world. It consumes annually over 25 per cent of the world's total output of raw silk. Yet, at present, not one pound of American-grown silk is found upon our markets. Experience has shown that the average of American-grown silk is superior to the average of that of any other country. Our climate seems to be specially adapted for the production of the finest grades of fiber. With millions of acres of cheap land suitable for growing the mulberry, and with our intelligent and inventive population, there seems no reason why we should not grow all the silk we manufacture, and even export fiber to other countries.

The following figures relating to importations and silk manufactures in the United States are taken from the census of 1900, and the annual report of the Bureau of Statistics of the United States Treasury for the same year:

Articles Imported.		Quantities in Pounds.	Value in Dollars.
Unmanufactured silk—			
Cocoons	duty-free	30,004	$18,235
Raw, or as reeled from the cocoon	duty-free	11,259.310	44,549,672
Waste	duty-free	1,784,404	761,853
Total unmanufactured			45,329,760
Manufactured silk—			
Clothing, ready-made, and other wearing apparel	Average ad valorem duty 53.95 per cent.		1,657,641
Dress and piece goods			15,425,997
Laces and embroideries			3,206,857
Ribbons			1,811,644
Spun silk, in skeins, cops, warps, or on beams		2.420,552	3,723,348
Velvets, plushes, and other pile fabrics		708,354	2,316,115
All other			2,752,771
Total manufactures			30,894,373

SILK GOODS IMPORTED INTO THE UNITED STATES FROM 1884 TO 1900 INCLUSIVE.

Year.	Declared Value in Dollars.	Duties Collected in Dollars.	Year.	Declared Value in Dollars.	Duties Collected in Dollars.
1884	$38,030,574.00	$18,962,210.34	1893	37,919,948.92	20,310,258.74
1885	28,106,797.57	14,000,210.04	1894	24,160,529.28	12,824,084.74
1886	28,055,854.94	13,938,096.61	1895	31,023,148.18	14,739,550.46
1887	31,264,276.58	15,546,300.70	1896	26,627,731.71	12,504,006.17
1888	32,942,629.03	16,351.685.48	1897	26,517,092.51	12.421,970.09
1889	34,956,728.77	17,342,571.54	1898	22,639,596.93	12,231,680.65
1890	38,246,787.20	18,945,959.24	1899	25,026,504.01	13,506,312.23
1891	37,300,387.27	19,368,764.49	1900	30,358,777.39	15,771,795.93
1892	31,442,180.31	16,965,637.03			

SILK MANUFACTURES IN UNITED STATES IN THE CENSUS YEARS 1890 AND 1900.
(Special Report, Census Bureau.)

	1900.	1890.	Per Cent of Increase.
Number of establishments	483	472	2.3
Capital	$81,082,201	$51,007,537	59.0
Wage-earners, average number	65,416	49,382	32.5
Total wages	$20,982,194	$17,762.441	18.1
Miscellaneous expenses	10,264,208	4,259,623	141.0
Cost of materials used	62,406,665	51,004,425	22.4
Value of products	107,256,258	87,298,454	22.9

IX.—Climatic and Labor Factors in Silk Culture.

Italy is second only to China in the quantity of her output of silk; but in quality and value she surpasses by far every other country. The highest grade of Italian silk is produced in the three Northern provinces of Piedmont, Lombardy and Venetia. These provinces form a vast alluvial plain extending from the 45th to the 46th parallels of north latitude, from east to west about 230 miles. This plain is watered by the river Po and its tributaries. It lies just at the foot of the Alps and is swept by cold wintry winds, which frequently cause the thermometer to fall below 10 degrees F., or 22 degrees below the freezing point. Besides silk—the main agricultural staple—the most important products of this region are wheat, corn, barley, rye, millet and rice. Dairying, especially cheese making, is an important industry.

During the year 1895 in these three provinces silk growing furnished the principal employment and support of about 4,000 men, 10,000 women and 30,000 children. The climatic data, given on the following pages, shows that the best silk-growing region of Italy has a climate very similar to that of the central Northern States of the Union.

In the United States, as elsewhere, silk growing must be looked on mainly as work suitable for labor otherwise unproductive. The actual cost of growing silk has never been studied in this country. But we have very complete figures for European countries. The following is a sample calculation of the cost of raising the produce of one ounce of silk-worm eggs in Italy:

Dr.—	
To "seed," one ounce	$2.00
To mulberry leaves for feed	12.00
To rental of trays and apparatus	4.00
To labor, 30 days	9.00
To heat and light	2.00
To brush for cocooning	1.00
Total	30.00
Cr.—	
By 130 pounds of cocoons @ $0.38	49.40
By resulting manure	1.50
Total	50.90
Less cost	30.00
Net return	20.90

In America under the conditions we have named the cost of labor may be omitted from our calculation. The cost of mulberry leaves may be placed at about one-fourth that given above. With a duty of 25 per cent *ad valorem* on imported reeled silk it is probable that American-grown cocoons will bring not less than 50 cents per pound! The best class of Indian cocoons now sell in the London market for about 75 cents per pound. This class of silk can be produced in the South Atlantic, Gulf and Lower Mississippi Valley States as cheaply as in India. It will add enormously to the value of our other textile fibers, since these silks are well adapted for mixing with other fibers to make durable goods. The castor-oil plant flourishes luxuriantly in the South, while many of the other favorite food plants of the Indian worms are known to thrive in the hot climate and light soils of the cotton region.

In practical silk growing, at least eight-tenths of the entire labor is done by women and children of the family—whom our social customs will not permit to do ordinary field labor—and by men too old or too feeble to do even the lighter kind of field work. Such labor as this has little or no commercial value. The establishment of silk-growing industry in the United States means the utilization of this labor now unproductive. It will mean the addition to many families of an increased income of from $60 to $250 per year without much outlay for material or any hardship to the workers. The work of tending silk-worms is easy, clean and pleasant. It is work that children and women of culture and refinement delight in. By raising from two ounces of eggs two broods of silk-worms annually, a child of twelve or fourteen years may, in ten weeks in early spring, earn money enough to purchase clothing and school books for the entire year, or the means of taking a summer vacation and travel. There are at least 50,000 families in North Carolina which can each year rear the product of four or five ounces of silk-worm eggs, and this without interfering with the regular work of the household. The additional income thus produced would amount for the entire State to over $3,000,000. This large sum being produced by the labor of the indoor members of the family, would naturally go for purchasing increased comforts and luxuries for these. It would add just so much to the prosperity and enjoyment of rural life. It will in a single generation elevate the entire social condition of our country people, besides inculcating habits of self-reliance and thrift.

The reeling of the raw silk about doubles its value, therefore, if the $3,000,000 worth of silk-worm cocoons which the State may produce are reeled within the State, it will double the people's income from this source, although silk reeling is fit labor for otherwise productive men and women. Silk reeling can not be economically done by household labor.

In the silk-growing districts of Southern France, which adjoin the chief silk-growing region of Italy, the following scale of wages are quoted in a recent Consular Report of the United States Department of State: "Male laborers per day, 55 cents to 60 cents; male laborers per week, $3.30 to $3.60; male laborers per month, with board and lodging, $7.00 to $9.00. Female laborers receive about one-half the wages of males. The above figures are for ordinary farm labor only. For skilled labor, such as grafting vines, men get 80 cents to $1.00 per day. An ordinary day's work does not exceed seven hours. A day's work is nominally twelve hours, but laborers are allowed three rests of one and one-half hours each. Even then the laborer works with the placid deliberation of a man working against time. Their tools are rude and awkward."

The same report quotes for ordinary farm labor in the silk-growing districts of Spain the following wages: Men, 40 cents to 50 cents per day; in harvest, 70 cents to $1.00.

In Spain women are employed only at light work, such as gathering grapes, for which they receive about 15 cents per day. A day's work is 9 hours.

The report of the North Carolina Commissioner of Labor for 1899 quotes the following wages for farm labor in this State:

Men, per day, 50 cents; per month, $8.90, with rations and house equivalent to about $6.30. Women, per month, without rations, $5.27. Children, per month, without rations, $3.58.

Farm wages in North Carolina, compared with those abroad, are not higher than in Italy or Spain for the same class of work. Considering the greater cheapness of food, lower taxes and freedom from military service in America, even were American wages higher than they are, the more general use of labor-saving tools and our more intelligent labor will enable us to compete with similar labor anywhere.

TEMPERATURE AND PRECIPITATION.

DRAGUIGNAN. DEPARTMENT VAR, FRANCE.

Latitude 43° 32′ N. Longitude 4° 8′ E (Paris). Elevation 584 feet.

Year.	Jan.	Feb.	March.	April.	May.	June.	July.	August.	Sept.	Oct.	Nov.	Dec.	Annual.
MEAN TEMPERATURE—DEGREES F.													
1883	41.7	46.8	42.6	51.4	59.4	67.5	73.0	74.5	66.4	54.0	49.5	43.0	55.8
1884	42.4	45.7	49.5	53.4	62.4	63.0	72.9	72.0	65.3	52.0	43.5	42.1	55.4
1885	39.0	47.3	48.7	53.8	60.1	67.5	74.3	74.1	64.2	53.2	50.9	43.5	56.4
1886	39.9	44.4	47.1	53.4	60.8	65.1	74.3	73.0	65.3	58.6	48.4	42.4	56.1
1887	37.6	41.2	47.7	52.0	58.1	69.6	73.8	73.4	64.6	49.6	48.0	41.9	54.8
AVERAGE PRECIPITATION, INCHES AND HUNDREDTHS.													
1883	6.92	4.00	2.18	4.69	7.83	3.13	0.35	0.30	3.82	1.14	2.24	0.52	37.12
1884	0.84	1.06	2.30	5.02	2.41	4.07	0.37	1.02	3.10	1.43	0.32	3.32	25.26
1885	3.06	3.26	0.89	5.55	0.86	6.00	2.37	3.11	2.54	9.02	5.76	0.18	42.60
1886	4.44	3.61	2.64	3.47	1.17	0.58	0.75	1.46	4.75	14.27	6.22	1.61	44.97
1887	6.02	6.61	1.77	4.37	0.63	1.58	0.87	2.16	0.59	0.76	6.50	2.91	34.77

NORMAL TEMPERATURE AND PRECIPITATION IN LOMBARDY, ITALY.

Stations.	Altitude Above Sea Level	January.	February	March.	April.	May.	June.	July.	August.	September	October	November	December	Annual.	Length of Record.
MEAN TEMPERATURE—DEGREES F.															
	Feet.														*Years.*
Como	367	34.0	38.5	44.8	52.5	60.1	67.1	72.1	70.0	63.0	52.9	42.3	36.3	52.8	11
Sondrio	1,191	33.4	38.8	44.8	53.4	60.3	67.1	72.3	69.6	62.8	52.9	41.9	36.1	52 8	2
Milan	482	33.4	39.9	46.8	55.8	63.5	70.7	76.5	73.9	66.9	55.6	43.5	36.1	55.2	23
Brescia	564	34.9	40.6	47.1	55.8	63.1	70.0	75.2	73.2	66.9	55.8	44.6	37.0	55.4	18
Bergamo	1,253	35.8	40.5	45.3	53.4	61.2	68.2	73.6	71.8	65.3	54.9	43.7	38.3	54.3	9
Pavia	322	33.1	39.7	46.9	55.9	63.7	71.1	76.1	74.1	67.1	55.6	43.5	36.1	55.2	17
Cremona	223	32.5	39.2	46.2	55.0	63.7	70.9	76.6	74.1	67.1	55.8	43.5	35.8	55.0	5
Mantua	131	35.1	40.5	47.8	57.0	64.9	72.7	78.3	75 7	68.7	57.4	44.8	37.8	56.7	17
AVERAGE PRECIPITATION—INCHES.															
Aosta		1.85	1.81	1.22	1.77	2.20	1.46	1.18	1.81	1.73	3.62	2.32	1.57	22.54	29
Biella		1.57	1.61	3.70	5.55	6.93	5.79	4.37	4.53	3.39	6.30	4.10	2.84	50.68	13
Milan		2.40	2.24	2.60	3.31	3.94	3.23	2.84	3.23	3.46	4.68	4.37	2.91	39.21	116
Brescia		2.05	1.81	2.16	3.66	4.41	5.04	3.70	3.31	2.40	3.82	4.06	2.56	38.98	10
Verolanova		2.44	2.36	2.13	4.88	4.84	3.50	3.11	2.52	2.28	4.17	4.10	2.52	38.85	10
Pavia		2.20	1.97	2.16	2.84	2.80	2.16	1.89	1.93	2.52	3.70	3.35	2.36	29.88	63
Mantua		1.30	1.30	1.73	2.36	2.80	1.97	1.81	1.97	2.40	3.31	2.72	1.69	25.36	39

TEMPERATURE AND PRECIPITATION.

SILCHAR, PROVINCE OF ASSAM.

Latitude 24° 49′ N. Longitude 92° 50′ E. Elevation 104.3 feet.

Jan.	Feb.	March	April.	May.	June.	July.	Aug	Sept.	Oct.	Nov.	Dec.	Annual	Length of Record. Years.
NORMAL MONTHLY TEMPERATURE.													
63.4	66.9	73.4	77.9	79.7	81.7	82.4	81.9	81.8	79.8	73.2	65.9	75.7	18–19
NORMAL MONTHLY PRECIPITATION													
0.64	2.48	7.95	12.81	15.70	19.38	20.43	18.21	14.12	6.20	1.09	0.66	119.67	30–31
AVERAGE MONTHLY MEAN RELATIVE HUMIDITY.													
75	70	72	76	80	85	85	86	84	81	76	76	79	16–18

DHUBRI, PROVINCE OF ASSAM.

Latitude 26° 7′ N. Longitude 89° 50′ E. Elevation 115.34 feet.

Jan.	Feb.	March	April.	May.	June.	July.	Aug.	Sept.	Oct	Nov.	Dec.	Annual.	Length of Record. Years.
NORMAL MONTHLY TEMPERATURE—DEGREES F.													
62.6	64.8	74.9	78.8	78.5	80.0	82.2	81.1	79.9	78.2	70.9	64.5	74.7	6–7
NORMAL MONTHLY PRECIPITATION.													
0.32	0.50	2.04	5.21	15.96	26.75	14.90	11.80	12.42	4.17	0.02	0.19	94.28	16–18
AVERAGE MONTHLY MEAN RELATIVE HUMIDITY.													
77	64	61	68	80	87	85	86	87	81	76	77	77	6–7

TURA, PROVINCE OF ASSAM.

Latitude 25° 30′ N. Longitude 90° 17′ E. Elevation ---- feet.

Jan.	Feb,	March	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.	Length of Record. Years.
NORMAL MONTHLY TEMPERATURE—DEGREES F.													
61.3	63.4	74.5	77.9	76.0	-------	78.0	77.3	77.2	74.5	68.6	6.30	-------	3–4
NORMAL MONTHLY PRECIPITATION.													
0.60	0.83	1.97	5.77	15.93	24.71	23.50	20.75	20.54	7.85	0.39	0.14	122.98	17–18

X.—Sketch of the Physical Geography and Climate of North Carolina.

The topography of North Carolina is strikingly diversified. The State lies between the parallels of 33 degrees 50 and 36 degrees 33 north latitude, and between 75 degrees 27 and 84 degrees 42 west longitude, and extends from the Atlantic Ocean on the east to the crest of the Smoky Mountains on the west. The extreme length of the State is 503 miles, its breadth 189 miles, and it occupies an area of 52,286 square miles, of which 3,600 square miles are water surface.

The State is naturally divided into three climatic regions. These divisions are called the Eastern, the Central and the Western Districts. In this subdivision the greater part of the Piedmont section is included with the Western District, as climatically nearer allied to the mountainous than to the central level portions of the State. The Eastern District embraces 36 counties, the Central 26, and the Western 34, each representing nearly one-third the area of the State.

Eastern District.

The Eastern District embraces that portion of the State extending about 100 miles westward from the coast, and includes the lower, or navigable portions of the larger rivers of the State. The drainage is towards the southeast; the land is nearly level, rising gradually to an elevation of about 250 feet in the western portion. To this district belong all the counties touching the sea, and it contains within its area all the swamp lands, lakes, sounds and bays of the State, besides numerous but generally small islands.

Central District.

The Central District includes the middle portion of the State from the western limit of the Eastern District to the Yadkin River. The topography of the surface of the country begins to change; it is no longer entirely level, but rolling, and in the western portion hills and valleys appear. The elevation varies from 250 feet on the east to 800 feet in the northwest portion. The drainage of the greater part is towards the south, but in the northern tier of counties the streams flow northward into the Dan, which, in its lower course, takes the name Roanoke River. The watershed between these two drainage areas is the broad ridge, having an elevation of nearly 800 feet, which extends eastward from the Blue Ridge through Stokes, Rockingham, Caswell and Person counties, terminating in the latter in the heights called Hagas Mountains, which attain an elevation of 1,000 feet.

Western District.

The Western District embraces all that portion of the State west of the Yadkin River, except the three counties of Stanly, Union and Anson. The portion east of the Blue Ridge is the Piedmont section. It has an average elevation of 1,000 feet, and is distinctly a region of mountains and valleys. The drainage takes place through the Yadkin, Catawba and Broad, the first two flowing towards the east and northeast, then making sharp bends to the south, the latter flowing directly south, all reaching the Atlantic Ocean through South Carolina. The upper basins of these three rivers are separated by mountain chains trending eastward from the Blue Ridge.

The climate of the State is fixed by its location in middle latitudes, and by its relative position to the general course of low areas or cyclonic storms in the United States. Situated between the parallels of 34 and 37 degrees north, the average climate of the whole State is strictly that of the warm temperate zone, modified by various causes. The modifying influences are the proximity of the ocean on the east, the general topography of the State, the configuration of the surface, the nature and covering of the soil, the drainage areas, and especially the mountain system in the west, which gives North Carolina a greater diversity in climatic features than any other region of similar area possesses. The eastern margin, which is thrust forward into the Atlantic, considerably beyond what would be normal trend of the coast line, has distinctly an insular or marine climate, that is characterized by uniformity, with small ranges in temperature, both diurnal and seasonal, and abundant precipitation. Towards the interior the influence of the ocean diminishes, the extremes of temperature are greater, the rainfall less; while in the western or mountainous section the effect of elevation predominates, giving cooler summers and a salubrious atmosphere.

The Gulf Stream, as a source of abundant heat and moisture, may well modify the course of sub-tropical cyclones, which, originating in the West Indies, travel northwest, and recurving about the parallel of 30 degrees north, move thence northeast along the Atlantic coast influencing for a few days the weather of this region.

MONTHLY, ANNUAL AND SEASONAL MEAN TEMPERATURES FOR THE DIFFERENT DISTRICTS AND FOR THE STATE.—DEGREES F.

	Jan.	Feb	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
Eastern District	43.6	46.0	49.5	57.8	67.4	75.1	78.8	77.2	72.3	62.4	52.7	45.2	60.7
Central District	40.7	44.2	49.2	59.8	68.2	75.7	78.7	76.0	69.8	59.2	49.1	43.2	59.5
Western District	38.5	41.8	46.0	56.3	64.1	70.9	74.4	72.2	66.2	55.3	45.6	39.8	55.9
State	40.8	44.3	48.0	57.7	66.9	74.4	77.8	75.8	70.2	59.7	49.7	42.7	59.0

	Spring.	Summer.	Autumn.	Winter.
Eastern District	58.2	77.0	62.5	44.9
Central District	59.1	76.8	59.4	42.7
Western District	55.5	72.5	55.7	40.0
For the State	57.5	76.0	59.5	42.6

The true mean temperature of North Carolina is 59.0 degrees F., which is the normal for twenty years. This is within half a degree of the calculated mean temperature of the northern hemisphere, which is 59.5 degrees, according to Ferrel. It will be noted that the mean temperature of the Central District corresponds very closely with the means for the State, and especially with the spring and autumn means. Autumn is much warmer than spring in the Eastern District, while they are about the same in the rest of the State. The increase of temperature is most rapid from March to April + 9.7 degrees, and from April to May, + 9.2 degrees; the most rapid decrease occurs from September to October, —10.5 degrees, and from October to November, —10.0 degrees. The coldest month is January, the warmest is July.

The average date of the first killing frost in North Carolina is October 10th, but light frosts occur early in September; the last killing frosts of spring occur most frequently in April, though some severe frosts have been recorded in May. The first killing frosts during the past few years have occurred on the following dates: 1888, September 30th; 1889, October 7th; 1890, October 28; 1891, October 9th. The last killing frosts of spring occurred in 1888, on May 15th; 1889, May 4th; 1890, April 21st, and in 1891, on May 8th.

The formation of ice to any considerable thickness is extremely rare.

The annual precipitation varies from 40 to over 70 inches, the average for the entire State being 53.29 inches, which is the normal for twenty years. North Carolina, therefore, belongs to the region of the United States which is characterized by the largest precipitation, the center of which is the Gulf coast, about the mouth of the Mississippi.

The averages for the different districts and seasons are as follows in inches:

	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
Eastern District	4.60	3.48	4.64	4.20	4.01	4.40	5.98	6.66	5.64	4.04	3.42	4.16	55.23
Central District	4.30	4.25	4.21	3.75	4.27	4.00	4.66	5.33	4.30	3.47	3.53	3.73	49.85
Western District	4.75	5.40	5.56	3.75	4.38	4.34	5.19	5.42	3.88	3.38	3.35	3.92	53.32
For the State	4.52	4.25	4.90	3.84	4.20	4.34	5.44	6.09	4.65	3.66	3.40	4.00	53.29

	Spring.	Summer.	Autumn.	Winter.
Eastern District	12.85	17.04	13.10	12.24
Central District	12.18	13.99	11.35	12.28
Western District	13.69	14.95	10.61	14.07
For the State	12.94	15.87	11.71	12.77

It is evident from this table that the distribution of precipitation is quite uniform throughout the year. The largest amounts occur in July and August, at the period when vegetation requires much moisture as well as heat. The driest months are October and November, when crops are no longer materially influenced by the weather. The wettest month has an average of 6.09 inches, the driest 3.40 inches; there is, therefore, no wet or dry season in North Carolina. Periods of drought are rare and of short duration, and, of course, no such thing as an entire failure of crops from this cause has ever been known. A short dry period almost always occurs in June.

For comparison with the figures above given for North Carolina we subjoin a short table of mean annual temperatures and rain-fall for the principal European cities, and for Tokio, Japan:

City.	Mean Annual Temperature. Degrees F.	Average Annual Rainfall in Inches.
Palermo	64.2	29.92
Venice	56.3	23.62
Rome	59.5	30.32
Paris	50.5	22.84
Berlin	48.2	23.32
Tokio, Japan	56.5	73.23
Madrid	56.3	14.96
Lisbon	60.1	28.74
Naples	60.6	32.68
London	50.5	24.02

For the above sketch of climate of North Carolina we are indebted to Climatology of North Carolina, published by the North Carolina Agricultural Experiment Station in 1892.

XI.—The Chemical and Physical Properties of Silk.

Silk is composed of carbon, 50.69 per cent; oxygen, 34.04 per cent; hydrogen, 3.94 per cent; nitrogen, 11.33 per cent.

The filament as it comes from the insect is double—that is to say, it is composed of two distinct threads laid side by side and united only by the natural gum or cement supplied by the insect. Each normal cocoon gives about 4,000 feet of filament, which has a diameter of about 1-2500 inch. One pound of this filament will measure about 1,846,590 yards. Silk is heavier than water, having a specific gravity of 1.36. The natural thread is coated with a sort of waxy gum, which forms about 23 per cent of the total weight of the thread. This gum is insoluble in cold water, but is soluble in water heated to 180 degrees F., and in dilute watery solutions of soda and potash. When freed from gum and fiber is readily dissolved by strong acids, concentrated alcohol, and ammoniacal oxide of nickel.

Silk in commerce is graded according to the following properties:

1. *Tenacity.*—This is the property by which the thread resists breaking when stretched. The tenacity of any sample depends chiefly upon the number of distinct filaments which enter into it. To facilitate comparisons silk reelers have agreed upon a standard thread of such size that 500 meters (1,640 feet) weigh just 1.62 grams (about 25 grains, Troy).

A good silk thread having a cross section of 1 square millimeter, 4-100 inch, should not break under a less strain than 95 pounds when freely suspended.

2. *Ductility.*—This is the property by which the thread stretches without breaking when pulled. Good silk should stretch 12.50 per cent of its length without breaking.

3. *Elasticity.*—This is the property by which the thread when stretched within the limits of tenacity tends to recover its former length. Good silk should, under such circumstances, recover over one-third the stretch.

4. *Hygrometricity.*—This is the property by which the thread holds water at ordinary atmospheric temperatures. Good merchantable silk should hold not more than 11.7 per cent of water at ordinary temperatures. This water can be evaporated only at about 275 degrees F.

XII.—Home-Spun Silk.

The scope of this Bulletin does not include the description of methods used in the manufacture of silk cloth. But as many small growers of silk will desire to work up their fiber, or at least the floss silk, into articles for home use, a few words on the cleansing and dyeing of silk will not be out of place here.

The natural silk thread as it comes from the reel or spinning wheel contains coloring matter, oil, gum and wax. About 23 per cent of the gross weight of silk consists of these matters. Most of these substances must be removed from the fiber before it can be dyed. The gum and wax are soluble in boiling water and in weak alkaline solutions—3 per cent sodium corbonate. Glossy or "brilliant" silks retain a part of their natural gum and wax, whereas "dull" silks have these substances entirely removed. It is considered undesirable to remove all of the natural gums, hence prolonged boiling, and heating to high temperatures are considered injurious to silks.

The water used in degumming silk must be of the softest kind and free from grit and sediment. No more water than is absolutely necessary should be used. Experience has shown that one gallon of water and two and one-half ounces of soap are sufficient to cleanse one pound of silk thread or yarn. One hour's simmering just below the boiling temperature should effect a thorough cleansing. The water should be first heated to boiling point and then cooled with a little cold water before the silk is added. Turn and stir the silk frequently. Before putting the silk to simmer tie several skeins into a hank, and the hanks of the same class and quality of silk into separate bundles of convenient size. Great care should be exercised in grading the silks in order to ensure uniform results. Tie the bundles to a brass—not iron—wire hoop and sink in a brass, or copper, or porcelain-lined kettle or vat. When the silk becomes white and soft, or free from gum, remove from first bath, wring, straighten the skeins and roll up in a coarse linen sack. Place sack in a fresh clean bath similar to the first and again simmer for one-fourth hour, stirring constantly. After second bath remove, rinse in clear water and wring out as before.

Silk thread for sewing, knitting and similar home uses is usually made from floss silk, which is combed and spun on a wheel in exactly the same way as linen thread. The silk thread, after being spun, is cleansed as above described and is ready for dyeing.

Dyeing Silk.

Silk takes and holds colors better than cotton or linen, but less so than wool. A mordant is always necessary. Alum is the one most used. It must be of the best quality and free from iron. The following recipes are from a standard German work on dyeing and are reliable. The quantities of the different substances prescribed are calculated in each case for 10 pounds of cleansed and dried silk thread:

1.—A Citron Yellow.

Dissolve 1¼ pounds alum in 20 gallons boiling water. In this soak the silk one-half hour, constantly stirring and beating; wring it out, and throw away the alum water. In same kettle boil for one-half hour in 20 gallons water 8 pounds safflower, ¼pound alum; strain and run into a tub. In this soak the silk for one-half hour, stirring and beating constantly; wring, rinse and dry.

2.—ORANGE YELLOW.

To the safflower, both above described (Formula, No. 1), add 2 or 3 ounces of soda carbonate and same quantity of annato. But first steep the silk a few minutes in the simple solution of safflower (Formula, No. 1.)

3.—A BUFF YELLOW.

For the amount of safflower used in No. 1 substitute 40 pounds turmeric, and proceed as in Formula, No. 1.

4.—A PINK.

Tie 15 pounds safflower in a coarse sack and immerse in running water until the yellow color is all washed out. Dissolve 2 pounds carbonate of potash in 4 gallons water and pour over the leached safflower in a clean tub. Let stand six hours; strain, add 3 ounces vinegar and 3-8 ounce sulphuric acid. In this bath, soak the thread 4 hours with frequent stirring and beating. Wring it out, rinse in running water and dry.

Dissolve 4 ounces cream of tartar in 10 gallons of water. In this steep the silk for three-fourths hour with constant beating; wring and dry.

5. A BRIGHT CRIMSON.

Dissolve 2½ pounds Roman alum in 20 gallons water; strain. In this steep and beat the silk 4 hours. Rinse and wring dry.

In 16 gallons water boil for 10 minutes: 1¼ pound cochineal, 1 pound powdered nut-galls, ¼ pound cream of tartar; strain, and in this steep the silk, with frequent beating, for 1 hour. Rinse, wring and dry.

In this recipe 3 pounds cudbear may be substituted for one-half the annato, but the color will be less desirable.

6.—A FINE NANKEEN.

(1) In 16 gallons water boil for 10 minutes 2 pounds powdered nut-galls; strain.

(2) In one-half gallon of water boil till dissolved one-half pound soap.

(3) Mix (1) and (2).

(4) In 2 gallons water boil 15 or 20 minutes 1 ounce annato, 4 ounces carbonate of potash; strain.

(5) Add one-half of (4) to (3).

In (5) steep the silk one-fourth hour with frequent beating. If color is not deep enough add more of (4). Remove, rinse quickly and dry.

7.—A Medium Blue.

(1) In 20 gallons water boil 10 pounds sulphate of iron.

(2) In 5 gallons water boil 10 pounds soap.

(3) In 20 gallons water boil 12 ounces prussiate of potash, and make it weakly acid with muriatic acid. Steep the silk in (1) for one-half hour. Rinse, wring and without drying steep in (2), kept just below boiling temperature, for one-half hour. Rinse and steep in (3) one-fourth to one-half hour. Rinse and dry.

8.—A Deep Blue.

For a very deep blue before steeping in (2), Formula 7, steep the silk one-fourth to one-half hour in a bath of one-half to one pound cochineal in 10 gallons water. Then proceed as in Formula 7.

9.—Green.

(1) In 100 gallons water dissolve Indigo, 5 pounds; copperas, 5 pounds; lime, 15 pounds. Strain.

(2) In 15 gallons water dissolve 2 pounds alum.

(3) In 20 gallons water boil for three-fourths hour 4 pounds quercitron. Strain. Add 8 ounces sulphuric acid. Steep the silk in (1) until it shows a light blue color. Rinse and wring dry.

Steep in (2) 2 hours; wring dry.

Steep in (3) until the desired shade of green is obtained.

Turmeric in varying quantities added to (3) will give different shades of green.

10.—Black.

Cleanse the silk thoroughly in soap and water. Steep until bleached in a solution of 1 pound sulphurous acid in 25 gallons of water. Rinse, dry and return to a fresh soap bath.

(1) In 10 gallons of water boil for one-fourth hour 7 pounds powdered nut-galls. In this boil the soaped silk one-fourth hour; remove from fire and let it steep for 36 hours longer. Rinse and wring.

(2) In 20 gallons of water, just below boiling temperature, dissolve 4 pounds sulphate of iron and 1½ pounds gum arabic. Simmer, but not boil, the silk in this for 1 hour. Remove from fire and let steep 12 hours. Rinse and wash in warm soapy water. Rinse and dry.

Note.—For cuts Nos. 7 to 11, used in this Bulletin, we are under obligation to the U. S. Department of Agriculture. Cut No. 5, supplied by Thos. Mehan & Son, of Philadelphia. Cut No. 15, by Bausch & Lomb Co., of Rochester, N. Y. The others were redrawn from various sources. In the preparation of the text we have drawn freely from standard Italian and French treatises, but are more especially indebted to the publications of the Chevalier Dr. E. Quajat, of the Royal Italian Silk Experiment Station at Padua.

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7.—A MEDIUM BLUE.

(1) In 20 gallons water boil 10 pounds sulphate of iron.

(2) In 5 gallons water boil 10 pounds soap.

(3) In 20 gallons water boil 12 ounces prussiate of potash, and make it weakly acid with muriatic acid. Steep the silk in (1) for one-half hour. Rinse, wring and without drying steep in (2), kept just below boiling temperature, for one-half hour. Rinse and steep in (3) one-fourth to one-half hour. Rinse and dry.

8.—A DEEP BLUE.

For a very deep blue before steeping in (2), Formula 7, steep the silk one-fourth to one-half hour in a bath of one-half to one pound cochineal in 10 gallons water. Then proceed as in Formula 7.

9.—GREEN.

(1) In 100 gallons water dissolve Indigo, 5 pounds; copperas, 5 pounds; lime, 15 pounds. Strain.

(2) In 15 gallons water dissolve 2 pounds alum.

(3) In 20 gallons water boil for three-fourths hour 4 pounds quercitron. Strain. Add 8 ounces sulphuric acid. Steep the silk in (1) until it shows a light blue color. Rinse and wring dry.

Steep in (2) 2 hours; wring dry.

Steep in (3) until the desired shade of green is obtained.

Turmeric in varying quantities added to (3) will give different shades of green.

10.—BLACK.

Cleanse the silk thoroughly in soap and water. Steep until bleached in a solution of 1 pound sulphurous acid in 25 gallons of water. Rinse, dry and return to a fresh soap bath.

(1) In 10 gallons of water boil for one-fourth hour 7 pounds powdered nut-galls. In this boil the soaped silk one-fourth hour; remove from fire and let it steep for 36 hours longer. Rinse and wring.

(2) In 20 gallons of water, just below boiling temperature, dissolve 4 pounds sulphate of iron and 1½ pounds gum arabic. Simmer, but not boil, the silk in this for 1 hour. Remove from fire and let steep 12 hours. Rinse and wash in warm soapy water. Rinse and dry.

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NORTH CAROLINA AGRICULTURAL EXPERIMENT STATION

B. W. KILGORE, Director

SILK-WORM FEEDING CHART

Calculated for Produce of One Ounce of Eggs

AGES.		APPROXIMATE QUANTITY OF MULBERRY LEAVES NEEDED.		SPACE REQUIRED IN TRAYS.	OPTIMUM TEMPERATURE OF REARING ROOM	REMARKS.
FIRST AGE.	1st day	1½ lbs.	Total, 10 lbs	10 square feet.	73 degrees F.	During this age give four meals each day progressively increased. Tender young leaves chopped fine. Feed at 6 a. m., 10 a. m., 2 p. m., 6 p. m. The worms molt on 5th day. Rarify as soon as recovered from molt. Give about 3 times as much space as before. Keep the air in room pure and dry, and the temperature uniform. Avoid drafts and noise.
	2nd day	1½ lbs.				
	3d day	4 lbs				
	4th day	1½ lbs.				
	5th day	1½ lbs.				
SEC'ND AGE.	1st day	6 lbs	Total, 30 lbs	30 square feet.	75 degrees F.	During this age give four meals each day. Use tender leaves, not chopped. Worms molt on 4th day. Rarify as soon as recovered from molt. Give about 3 times last space. Keep the air in room pure and dry, and the temperature uniform. Avoid drafts and noise.
	2nd day	8 lbs.				
	3d day	10 lbs.				
	4th day	6 lbs				
THIRD AGE.	1st day	8 lbs	Total, 110 lbs.	90 square feet.	76 degrees F.	During this age feed as before, only increasing quantity. Worms molt on 5th or 6th day. Rarify again. Give 3 times last space. Keep the air in room pure and dry, and the temperature uniform. Avoid drafts and noise.
	2nd day	26 lbs				
	3d day	30 lbs				
	4th day	30 lbs.				
	5th day	8 lbs.				
	6th day	8 lbs.				
FOURTH AGE.	1st day	30 lbs.	Total. 340 lbs.	270 square feet.	78 degrees F.	Feed as before but give mature leaves, unchopped. Worms molt on 6th or 7th day. Rarify as soon as recovered from molt, and give 3 times last space. Keep the air in room pure and dry, and the temperature uniform. Avoid drafts and noise.
	2nd day	40 lbs				
	3d day	60 lbs				
	4th day	70 lbs.				
	5th day	70 lbs.				
	6th day	40 lbs				
	7th day	30 lbs				
FIFTH AGE.	1st day	60 lbs.	Total, 1,900 lbs	810 square feet.	80 degrees F.	Feed four meals daily for first four days. 6 or 8 meals for 5th, 6th and 7th days. Four meals daily for remainder of this age. Worms show signs of spinning on 8th day. Prepare and place the brush on 9th day. Feed sparingly on 10th day. Preserve perfect quietness during spinning of cocoons.
	2nd day	90 lbs.				
	3d day	150 lbs				
	4th day	200 lbs.				
	5th day	300 lbs				
	6th day	380 lbs.				
	7th day	380 lbs.				
	8th day	200 lbs.				
	9th day	100 lbs.				
	10th day	40 lbs.				

Remove cocoons from brush on 10th day after spinning began. Select those wanted for seed, and immediately choke others by steam or dry heat. String the seed cocoons and keep in a dark room at about 70 degrees F. Make necessary arrangements for egg laying. GERALD McCARTHY,

Biologist.

☞ Post this Chart in the Rearing Room and Keep Your Eye on it.

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